POWER

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Candid Chats with the Man Higher Up

Or the One That Holds Executive Sway Over the Human Element in the Power Plant

Does everything seem to be running smoothly in the organization of which you have charge?

Do you think you are getting value received for the money you pay the men that operate and maintain your plant for you?

Or do you think there is a leak somewhere?

If you labor under the impression that your men *are* lagging on you, that you are *not* getting value received for your money, have you ever stopped to seriously consider *why* this is so?

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You know that in some respects the human organization in a power plant (or anywhere else, for that matter) may be likened to a storage battery. Each individual in the plant stands in the same relation to the organization as a whole as the individual cell does to the battery.

When each cell in the battery is in good shape—no cells reversed—the maximum potential may be obtained. But when one or more cells are reversed—pulling in the wrong direction—the potential is lowered just that amount.

It is the same way in the plant organization. When each man is doing his share—when all are pulling together—everything runs smoothly. Let one or more work at cross-purposes to the rest, and things are likely to happen.

The storage battery has to be charged once in a while. The frequency depends on the amount taken out. The booster is used for this purpose. By its aid the cells are re-energized—rejuvenated. You can't expect to always take out of a battery and never put in.

It is the same way with the men. You can't get something for nothing. It can't be done! Try boosting once in a while. Give credit where credit is due. The men will respond to such treatment just as surely as will the battery. Turn about is fair play.

Battery cells will in time wear out and have to be replaced. The useful life of a cell depends in great measure on the care taken of it. The less attention given the cell, the sooner you will have to replace it.

Same way with the men. Neglect their welfare—overwork or underpay them or wear them out fast—and you will have to replace them. That means breaking in new ones—always an expensive undertaking.

So consider the interests of the humans in your plant organization as you would have them consider the storage battery. And always remember that, with humans as with storage cells, YOU CAN'T GET MORE OUT THAN YOU PUT IN. You can come nearer accomplishing this with the human element than with the battery. With proper treatment your men will all pull together, have longer life and be in shape to do the work daily expected of them. But it will require a square deal from your side of the house.

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The whole thing in a nutshell is simply this:

Human nature is just about the same the world over.

Barring a few unfits, every man is possessed of almost limitless possibilities for good work and achievement.

But you can't get something for nothing anywhere—*not even much for little!* Everyone under your direction, from the man hauling out the ashes to the ones at the top, has feelings, ideals, aspirations.

Properly directed, the energies and activities of each one of them can be turned to useful and resultful purpose.

But if you expect great results from the organization of which you have executive control, *you will have to reciprocate!*

The sooner you take that to heart and act on it, the sooner you will realize that *it is the only way to get value received from the men in your employ.*

Contributed by H. G. GIBSON, *Washington, D. C.*

The Ford Plant Switchboard

By Thomas Wilson

SYNOPSIS—One of the largest direct-current switchboards in the world, containing 222 dark Tennessee panels. It is 424 ft. long and was built at a cost approximating $1000 per linear foot. Over 165 tons of copper was used in the board and a distribution system of 178 feeders. Gyrostatic voltage-balance detectors, motor-operated field rheostats, remote-controlled machine circuit-breakers with overload time-limit devices, an elaborate dispatching and signal system, and unusual safety precautions are the outstanding features.

In addition to its great size and high cost, the 250-volt direct-current switchboard in the power plant of the Ford Motor Co. has a number of interesting features in design and control which make it worthy of note. The board and the innovations in control equipment were designed under the direction of Fred Allison, electrical engineer of the company, who supplied the following information, taking it largely from a lecture previously prepared by him for a Detroit-Ann Arbor sectional meeting of the American Institute of Electrical Engineers.

The switchboard has a total length of 424 ft. and consists of 222 dark Tennessee-marble panels. These have the usual circuit-breaker, ammeter and 1000-amp. double-pole double-throw knife-switch (Fig. 1). The machine panels are on the engine-room floor, feeder and operating panels on the first balcony and additional feeder panels on the second balcony. All feeder panels have double-throw knife-switches, and on the machine-feeder panels the circuit-breakers are in duplicate. This is for the purpose of connecting either way on a three-wire bus system.

Supports for the Busbars

Current is conducted from each generator by copper busses made up of 30 pieces of copper 6x0.25 in. The busses lead directly from the machines to the circuit-breaker panels through a specially designed runway, which is screened and guarded to eliminate any possibility of contact. In the basement runway the copper bars are suspended from the ceiling by hangers spaced at intervals of 4 ft. After passing the circuit-breaker panels, they are carried upward to the main bus directly behind the second-floor balcony. The main bus at this point is supported rather than suspended and is anchored from the ceiling as a precaution against buckling. It extends the entire length of the board, but tapers down to meet the relative demands of distribution with an ample margin of safety. All copper was installed with a working density of 750 amp. per sq.in. The rear of the first-balcony board alone contains 120 tons of copper, while the total amount used in the entire installation, comprising but one-half of the ultimate output, is approximately 165 tons.

The generator circuit-breakers, Fig. 3, are all of the triple-pole double-throw type controlling the positive, negative and equalizer leads and providing alternative connections with either of the two sets of busbars. While equipped for remote control, they are, in spite of their large size and liberal contact areas, capable of being closed easily by hand. They are equipped with direct-acting overload time-limit features and with reverse-current actuation, thus insuring protection to the generators against short-circuits or unduly sustained overloads and also against motoring currents.

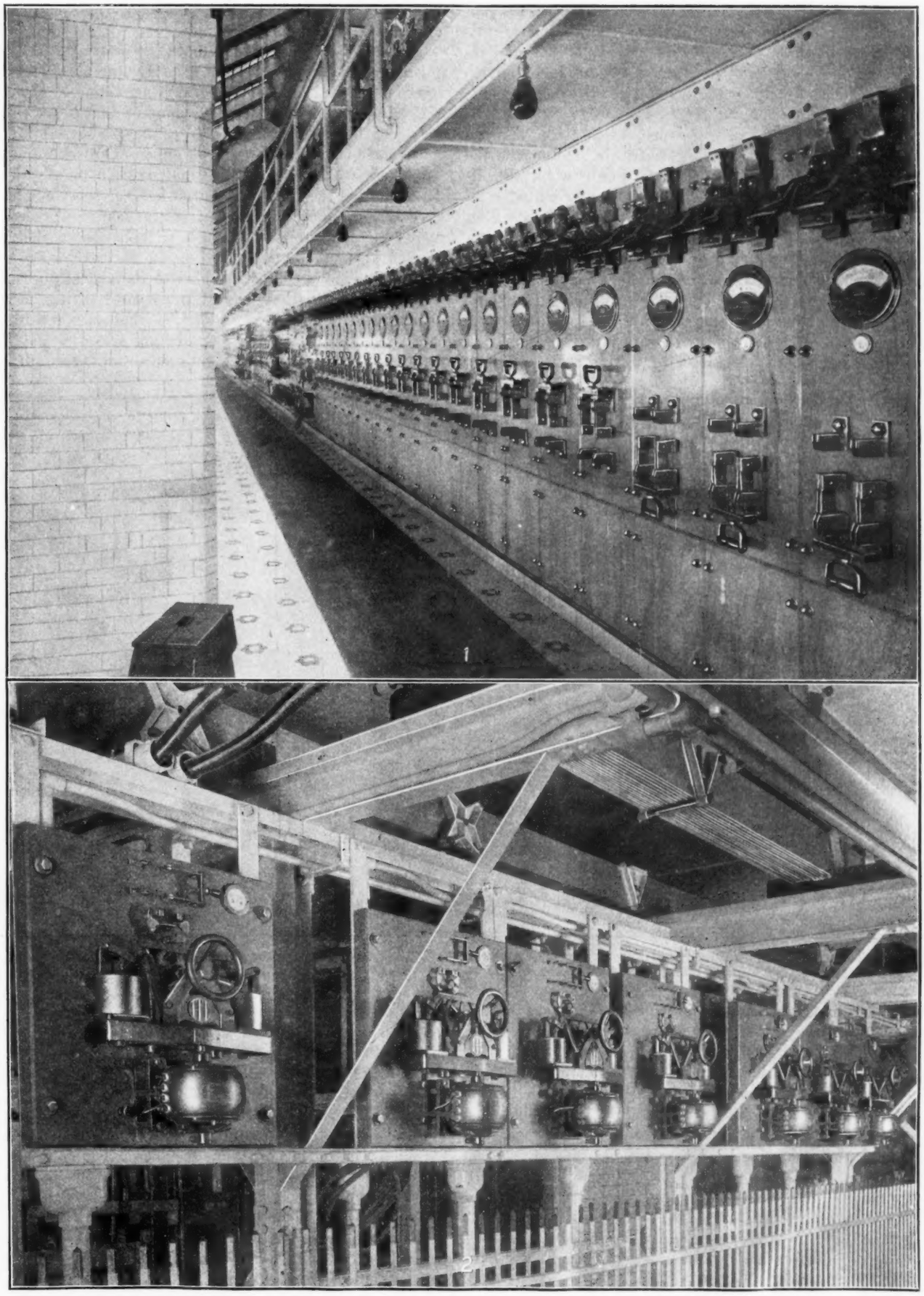
Remote Control and Interlocks

The remote-control mechanisms are operated by means of motors, shown at the bottom of the figure, there being one for each pole. Directly associated with these are interlocking devices so arranged that the poles of the circuit-breaker may be closed only in predetermined sequence—the equalizer first, then the positive and finally the negative pole. While the circuit-breaker is in full-open position, positive and negative switch members of both throws are locked out and only the equalizer members are free to be moved to the closed position; whichever throw of the equalizer is closed, the other is thereupon locked open, while that positive pole corresponding with the closed equalizer pole is at the same time unlocked. The subsequent closing of this member unlocks the corresponding negative pole. The interlocks referred to are mechanical and are effective whether the apparatus is operated electrically or by hand. Electrical interlocks are also provided as a further safeguard when the apparatus is closed electrically.

Of almost equal interest to that of the circuit-breakers and contributing in no small degree to the ease with which the various generating units may be controlled are the motor-operated field rheostats, shown in Fig. 2. The use of these mechanisms allows the placing of the rheostats at a distance from the switchboard and at the same time permits the regulation of the voltage of all the generators from a central control board, thus facilitating the operation of throwing a generator into parallel with others and of securing proper subdivision of the load between the various units.

Gyrostatic Voltage-Balance Detector

When putting a generator in parallel with others already loaded, the importance of having the voltage of the incoming machine bear a proper relation to that of the busbars before connection between them is established is generally recognized. In the Ford plant the customary method of depending on the correctness of a differential voltmeter and upon the exactness of the operator in reading it has been cast aside. The requirements are met by a device known as the gyrostatic voltage-balance detector, shown in Fig. 4. This device is made to control the circuit of the closing motor associated with the negative pole of the generator circuit-breaker. It consists primarily of a pair of switches in series with each other and connected in the previously mentioned motor circuit, as indicated in Fig. 5. The movable members of these switches are under the control of respective gyroscopic governors mounted on a vertical shaft adapted to be rotated by a motor placed immediately below it. During the period of use the field winding of this motor is connected across the mains of the 250-volt circuit, while its armature is at the same time subjected to the



FIGS. 1 AND 2. FEEDER AND OPERATING SWITCHBOARD PANELS AND MOTOR-OPERATED FIELD RHEOSTATS, RESPECTIVELY

potential difference that exists between the associated generator and busbars. The direction of rotation of this armature depends, therefore, upon whether bus or generator voltage predominates, and its speed in either direction depends upon the extent of the voltage difference.

By means of a specially designed clutch placed between the motor and the governor shaft, the motion of the former is transmitted to the latter only when the direction of rotation is that caused by a predominance of generator voltage over bus voltage. When rotating in the opposite direction, the motor runs free. An automatic cutout interrupts the motor armature circuit should the voltage difference attain such magnitude as to produce a dangerously high speed of rotation. The "low-speed" contact is normally closed. The circuit-breaker in conjunction with which this apparatus is employed is of three separate poles, as shown in the figure, closed in predetermined sequence; the equalizer pole is closed first and with it auxiliary contacts which control the field and armature circuits of the gyrostat motor. Before it is called upon to function, the motor has time to assume the speed of rotation corresponding with the voltage impressed upon the armature. When the motor is energized in the direction corresponding with generator voltage predominating over bus voltage, the governors, which are under the control of calibrated springs, will assume positions corresponding with the particular speed of rotation, the action of the governors being independent of each other up to a certain speed, beyond which, as the result of links connecting them with a slight lost motion, they act as a unit.

It has been stated that the rotation of the governors occurs only when the direction of voltage difference is favorable to paralleling. When the magnitude of this voltage is such as to give the governor shaft a certain speed of rotation, then the high-speed contact is closed. The minimum voltage difference necessary to accomplish this is, in the case of the particular apparatus in question, 2 per cent. of the normal bus voltage. Should the voltage difference, however, amount to 2.5 per cent. or more, the lower or high-speed contact is opened. The lower member of the low-speed contact is pivoted and is drawn toward its upper or normal position by a spring. If, therefore, the speed of rotation advances beyond that necessary to cause engagement of the low-speed contact members, they are free to move in response to the increased pressure communicated by the governor. The return of the lower contact member to its normal position, under tension of the previously mentioned spring, is resisted by the action of a dashpot, so that such return is made but slowly. The effect of this action is as follows: Suppose the voltage difference and speed to be excessive, then the high-speed contact is opened and the low-speed contact closed, its lower member being depressed through an angle proportional to the excess of speed. If now the voltage suddenly falls to a value below normal, the high-speed contact immediately moves to the closed position, while the upper member of the low-speed contact is simultaneously withdrawn from engagement with its companion member. The latter being retarded in its upward movement by the dashpot prevents contact being maintained at this point while it is being established at the high-speed contact, thus preventing the device from making the necessary connection while the voltage is changing rapidly through the normal value.

The battery used for ignition and circuit-breaker control is located in an especially designed room situated some distance from the switchboard and prime movers

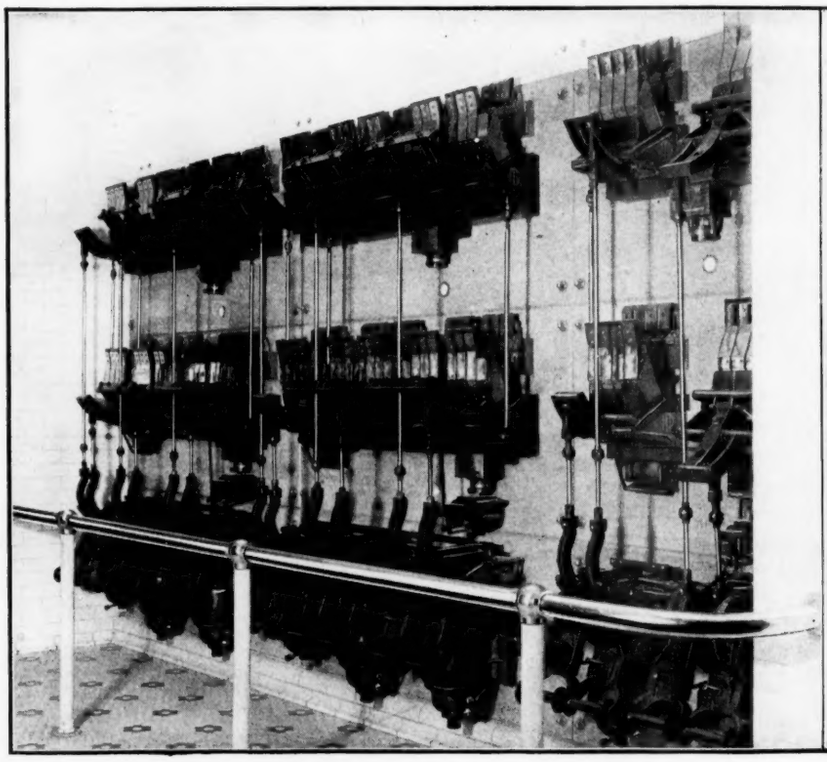


FIG. 3. MOTOR-OPERATED GENERATOR CIRCUIT-BREAKERS

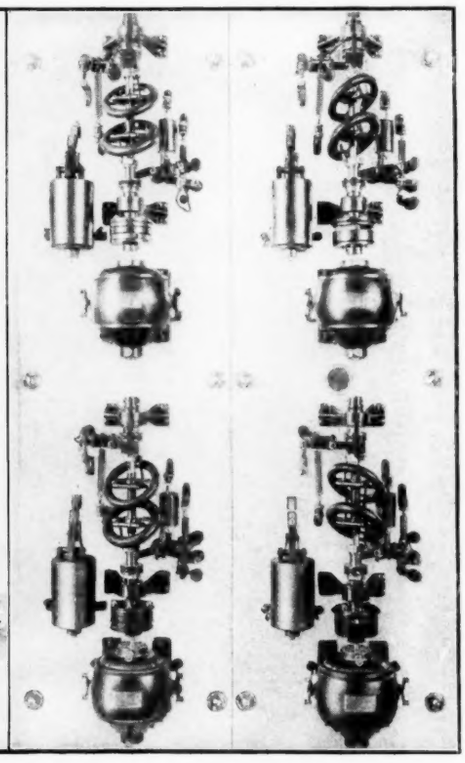


FIG. 4. GYROSTATIC VOLTAGE-BALANCE DETECTOR

in order to completely eliminate the corrosive effects upon all exposed metallic parts. This battery consists of 120 cells of 11-plate chloride accumulators. A balanced load was obtained by an even distribution of the ignition circuits, there being a three-wire system to each engine direct, one side of the igniters being connected to the positive and neutral while the other side is tapped to the negative and neutral.

In the factory, which has a covered floor space of 47.5 acres, over 8000 power machines used in the production of cars require a large number of motors, and there are other motors to drive ventilating fans, pumps, etc., besides the lighting for the various buildings. The distribution of so much current demanded an economical system. From the feeders, of which there are 178, current is distributed to the various departments by means of 1,000,000-circ.mil cables. After leaving the panels the cables are conducted on an aërial over the machine shops to different parts of the factory. The rack provides for 90 pairs of cables, but at present holds only 50. It is so designed that its carrying capacity may be doubled without taxing the roof or rack. The buildings farthest from the power house are fed by underground conduits. After entering the various buildings, the cables are led to distributing boards.

For the purpose of giving as far as possible continuous and satisfactory service on all lines, an elaborate dispatching and signaling system has been installed. On the second balcony a 200-pair telephone switchboard connects with every distribution center throughout the factory and with the boiler room, ashroom, gashouse and all engine-operating stands. In the office there is in connection with this dispatch board a signal board consisting of four panels, each carrying 300 designating lamps. When a feeder circuit is in operation, a green lamp shows up on the board, but when the circuit is out of operation a red light replaces the green. A duplicate set of telephone terminals is used in connection with the board, making it possible to locate and remedy any trouble within the system.

The upper panel of the board carries a totalizing meter which shows the entire load of the power house, an ammeter showing the individual load of each generator, and a duplicate set of running and operating lights which serve as a means of communication between the switchboard attendant and the engineer. On the signal board at the engine is an ammeter indicating the generator current, two voltmeters showing the voltage on the respective sides of the three-wire ignition circuit, a switch for completing the ignition circuit independent of the auxiliary switch associated with the generator circuit-breaker, and four signaling switches each of which is associated with a signal lamp having a distinctively colored bull's-eye lens. A signal given by the engineer lights the corresponding lamp at the switchboard. At the latter point a bell rings in order to insure the prompt attention of

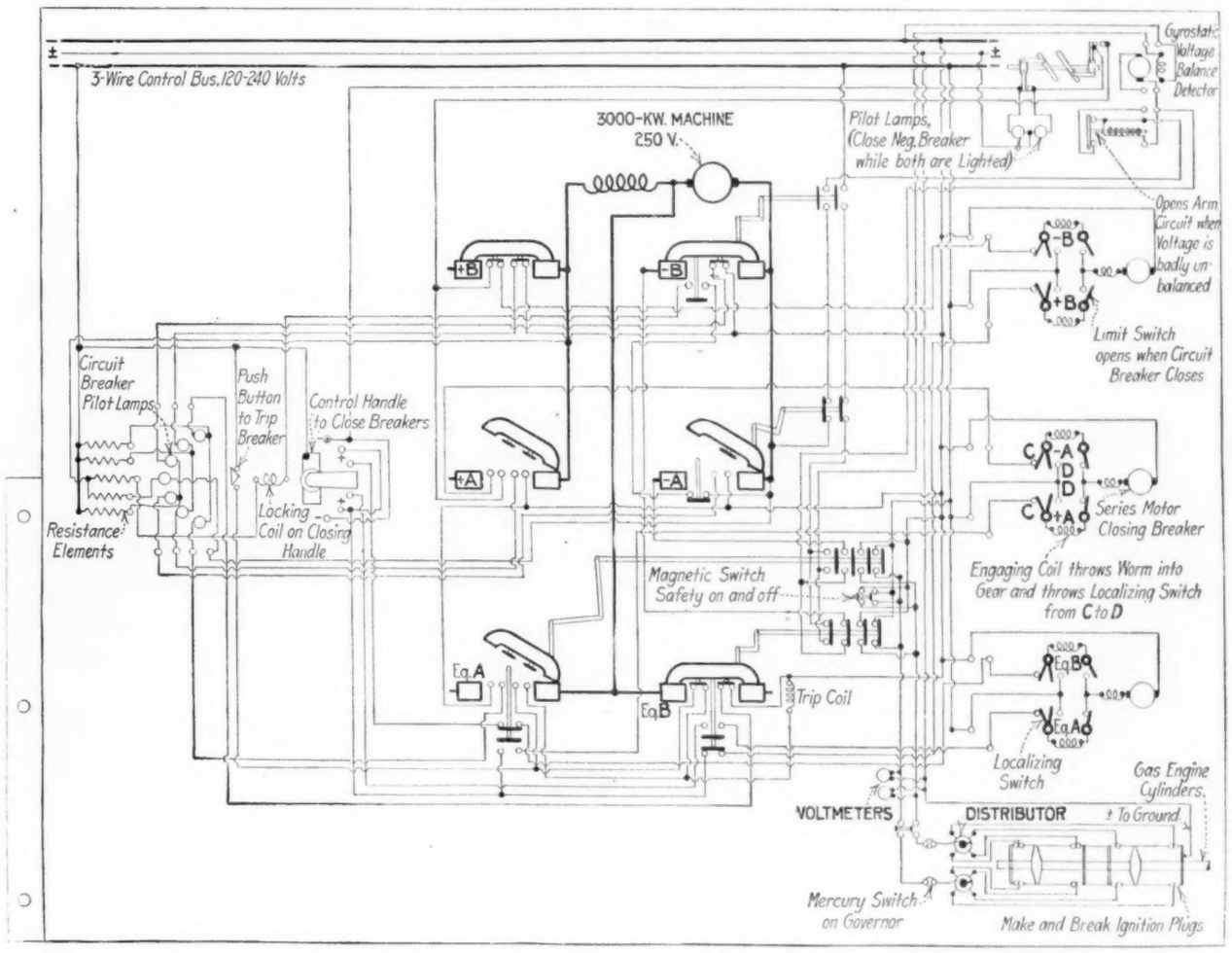

3-Wire Control Bus, 120-240 Volts
3000-KW. MACHINE 250 V.
Gyrostatic Voltage Balance Detector
Pilot Lamps, (Close Neg. Breaker while both are Lighted)
Opens Arm Circuit when Voltage is badly unbalanced
Limit Switch opens when Circuit Breaker Closes
Circuit Breaker Pilot Lamps
Push Button to Trip Breaker
Control Handle to Close Breakers
Resistance Elements
Locking Coil on Closing Handle
Series Motor Closing Breaker
Engaging Coil throws Worm into Gear and throws Localizing Switch from C to D
Magnetic Switch Safety on and off
Eq. A
Eq. B
Trip Coil
Localizing Switch
Gas Engine Cylinders
VOLTMETERS
DISTRIBUTOR
± To Ground
Mercury Switch on Governor
Make and Break Ignition Plugs

FIG. 5. WIRING FOR CIRCUIT-BREAKER CONTROL AND IGNITION SYSTEM

the operator. Both the lamps at the signal board and at the switchboard remain lighted until the operation called for has been performed. The indications of the respective lamps are as explained in a previous article: White, engine running, connect generator; green, increase load; amber, decrease load; red, engine trouble, disconnect generator.

At the switchboard there are two other signal lamps, which indicate whether the ignition circuit is completed through the short-circuiting switch at the signal board or through the auxiliary switch controlled by the circuit-breaker. The need for these is determined by the fact that the generator circuit should be completed only after the ignition and throttle control circuit has been put under control of the circuit-breaker, thereby insuring that upon the opening of the circuit-breaker the engine will be controlled entirely by steam.

In the power plant as well as the shops safety-first principles have been generally adopted. In the handling of the current from the generators an almost incredible amount of copper has been used. It would have been out of the question to have attempted any kind of insulation, but possibility of accident has been removed by screening in all bus runs throughout the power house. The danger to switchboard attendants has been minimized by inlaying in the floor a strip of cork 38 in. wide along the entire front of the board. The rear of the switchboard on both balconies is inclosed by a substantial safety fence about 5 ft. in height, the gates to which are kept locked at all times and entrance can be gained only after securing a key from the office.

The circuit-breakers, motor-operated field rheostats and other electrical control were built by the Cutter Co., of Philadelphia, under the direction of Mr. Allison.

A Powdered-Coal Stock Job

SYNOPSIS—Our readers are inquiring about the Powdered Coal Engineering and Equipment Co., of Chicago. Investigation shows it to have splendid offices but no shop, a spectacular demonstrating plant but no installations, and to be devoting its activities to the selling of stock rather than machines. The process appears to be no better than others previously tried or now upon the market, and if it were a great deal better, it would not justify the extravagant claims presented in the advertisements.

There has recently been undertaken in the public press an advertising campaign which it seems to *Power* should be analyzed for the sake of the truth in advertising and the protection of possible investors. The advertisements in question are those of the Powdered Coal Engineering and Equipment Co., of Chicago, which have recently appeared in such daily papers as the Baltimore *Sun* and the Chicago *American*, and such magazines as *Modern Methods* and *Illustrated World*.

The latest example of this attempt to induce investment appeared in *Modern Methods* for January. A glimpse at these sixteen pages of stock-selling endeavor leaves one with the impression of the old-time gold-mining prospectus, wherein fortunes were represented as to be made if only the money could be had for the development of the property.

It is the apparent intention of the article to impress the reader with the thought that Mr. Pruden has discovered a basic principle of physical and chemical character. This is indicated at the very outset of the article in question, where the burning of powdered coal is stated as "demonstrating a new principle in heating" and is compared to the basic inventions of Bell, Edison, Marconi, Wright and Westinghouse.

As a matter of fact the demonstration in question, involving the burning of pulverized coal in suspension, was first made about the middle of the last century and has been made in various forms by numerous inventors since.

The unscientific phrasing of much of this article is well illustrated in the very title of the equipment itself. No opportunity is lost to use the word "carburetor" and "carburization" in this connection. Since the meaning of carburize is "to combine with carbon," the phrase "carburization of coal" is obviously absurd and illustrates the fundamentally unsound and unscientific nature of the whole proposition.

As an example of a paragraph implying the monopolistic control of the principle of burning powdered coal, the following will serve:

> Just think of it—FIVE HUNDRED MILLION DOLLARS wasted in the United States alone EVERY YEAR. Are those not figures to stagger the imagination? Is that not an appalling consideration in this era of so-called efficiency? And the Pruden coal carburetor can and WILL put a stop to this monumental wastage, for it solves the problem of COMPLETE CARBURIZATION OF ALL THE COAL THAT GOES INTO THE FURNACE.

Does this not give the idea that this so-called invention is alone able to stop the appalling waste so emphatically mentioned? Again:

> Do you believe that ANY INVENTION WHICH WILL DOUBLE OR TRIPLE THE POWER-PRODUCING VALUE OF COAL OFFERS YOU AND ALL THE WORLD A WONDERFUL OPPORTUNITY? It doesn't take a mathematician to figure it out. Yet that is what the Pruden Process will do, AND IS DOING in this demonstration plant I am going to tell you more about.

It will not require much analysis on the part of the engineer to recognize the wonderful possibilities in any invention that will double or triple the power-producing value of coal. Another choice example of the consistent attempt to imply monopolistic control of the ability to burn powdered coal is illustrated in the thought expressed at the top of the fourth page of the article in question, wherein it is set forth as an invention of Mr. Pruden, that he first thought of the process of introducing powdered coal into the firing chamber thoroughly mixed with air. Again the involved and mystifying phraseology is employed.

> Now, thought Mr. Pruden, if I can inject powdered coal THOROUGHLY MIXED WITH AIR into my firing chamber, I can insure COMPLETE AND IMMEDIATE CARBURIZATION OF EVERY PARTICLE IN THE COAL. So he started to work inventing a method of mixing the coal dust and the air in proper proportions, a practical coal carburetor.

The painful history of Mr. Pruden's development of this fundamental and amazing discovery is set forth in the relation of his long and tedious experiments, taking

years of study and scores of experiments. Another paragraph sets forth the difficulty experienced by the inventor in getting the coal in the right condition for the work. "Scores, perhaps hundreds of experiments failed because the fact had not been revealed that in order to get perfect results the coal must be absolutely dry." "Then it was hard to get coal powdered finely enough to insure the best results. All this meant more experiments. At last coal, ground to the fineness of an almost impalpable dust, and dry of all moisture, was secured by Mr. Pruden." The fact that the coal must be dry has long been known to workers in this field. Plants including driers are not at all uncommon, and all that Mr. Pruden needed to do—if indeed it was not all that he did—was to go to one of the established manufacturers of this sort of equipment and buy the pulverizing machinery complete, guaranteed to produce a certain amount of product of the required degree of fineness, which degree has long been the subject of specifications. The thought which the writer of this advertisement evidently intended to be read between the

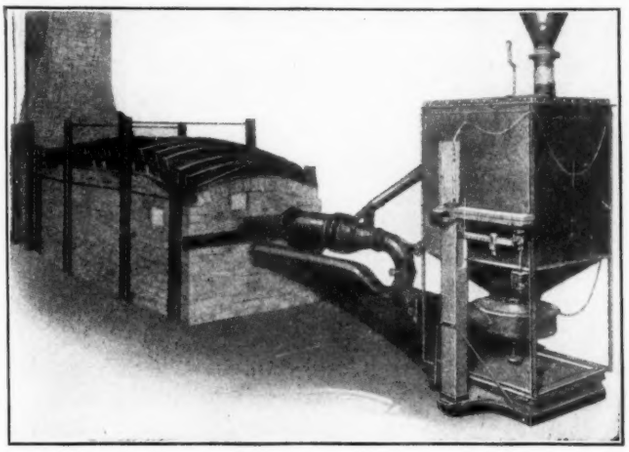


FIG. 1. THE DEMONSTRATION FURNACE

lines is that Mr. Pruden was not only the originator of this machinery, but was the one who discovered the necessity for fine grinding and complete drying.

The apparatus, Fig. 1, with which the demonstrations are made is a fuel feeding and burning device in conjunction with a simple furnace 4 ft. wide and about 14 ft. long, with a flat hearth and bung roof. It is on the order of a reverberatory furnace, but was designed merely as a container for the flame to be produced by the combustion of the powdered coal. The utter absurdity of the claim, that burning a few pounds of powdered coal in a firebrick box proves that enormous sums of money can be saved annually in the multitudinous variety of furnaces in this country, is obvious. Even supposing that the locomotive was thereby eliminated from consideration, would it naturally follow that from this demonstration powdered coal could therefore be successfully applied to the annealing furnace with its low temperatures and neutral flame? And even granting that this proved its adaptation to the annealing oven, would it necessarily follow that it would therefore be successful in the high temperature of the melting or puddling furnace?

He took Mr. Power to his experimental plant and showed him the furnace. He had it started and proved what he claimed. He showed Mr. Power that with 90-cent coal he was doing the work that double the amount of $3 coal would do. One ton of mine waste was producing the amount of heat that the two tons of $3 coal would be required to produce under the old wasteful methods. He showed him the stack free of smoke, he showed him a furnace floor free of cinders, he showed him heat of tremendous intensity produced in the time it takes an ordinary furnace to get warmed up. He showed him the doing away entirely with stokers or firemen with one man having plenty of leisure to look after half a dozen or more installations. He showed him in HARD FIGURES, such as a banker could understand, why the Pruden Process could cut at least $200,000,000 a year off the fuel bills of the United States.

It is quite an easy matter to claim that one has a field all to himself, and if the matter rests there, no

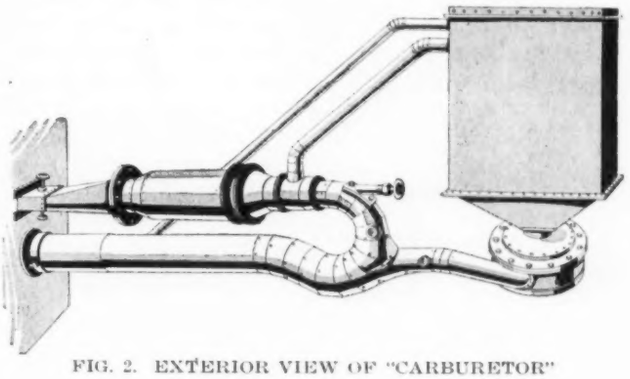


FIG. 2. EXTERIOR VIEW OF "CARBURETOR"

particular harm is done; but when one secures money on the strength of an implied contract which is nonexistent, it becomes something closely akin to fraud. Every railroad in the country *is* considering the problem of powdered coal, but the published statement that "it is more than probable that the first orders the company will have to fill will be to equip railroad locomotives with Pruden installations" serves as deceptive assurance. It is certainly implied in the paragraph containing this quotation that there does not now exist any locomotive equipped with powdered-coal burning apparatus, and it is quite as much to be inferred therefrom that this company is prepared to take and execute such contracts.

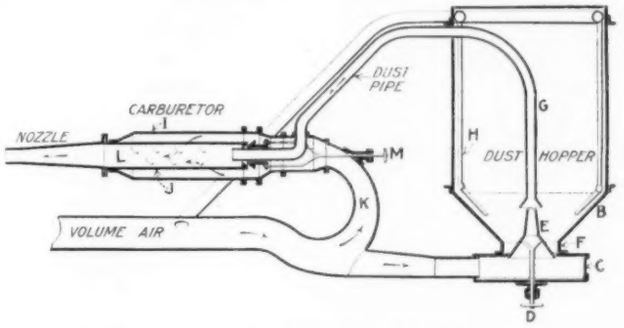


FIG. 3. SECTION THROUGH "CARBURETOR"

Readers of *Power* do not need to be told that there are at least two substantial concerns now actively engaged in this work on at least four different railroad systems, and that technical details have been elaborately developed and adequately protected by patent issues. The innocent investor buying this stock on the strength of the statement quoted could with justice claim to have been misled.

To use statistics applying to the total number of locomotives and thereby implying the total number of opportunities for the installation of this system is, to say the least, misleading. No such outcome or any approach thereto is commercially possible. This is in line with

the claim set forth in large type, that "it must be remembered that ALL THE EXPERIMENTAL WORK HAS BEEN DONE." "He goes to YOU with a perfected, tested, and PROVED invention that is past the experimental stage." The investor is given to understand that the equipment illustrated in the article is that which is going to make for him the millions of dollars claimed by the author.

Details of So-Called Carburetor

The so-called carburetor is shown in full and in section in Figs. 2 and 3. There is a sheet-steel hopper with a closed top and conical bottom *B* terminating in a short cylindrical section *C* to which is attached a threaded bearing. In the bottom of *C* there is a screw *D* which carries the conical valve *E*. This conical valve seats in a similar-shaped body *F*, which is attached to the bottom of the hopper. Extending upward from the valve *E* is a nozzle through which air from the compartment *C* can pass. This is placed on the same center line as the pipe *G*. It is obvious that with air blowing from the nozzle there will be created a slight suction due to the injector effect of the related parts.

The object of this device is to remove powdered coal from the hopper by means of the ejecting effect described. The conical valve *E* is lowered enough to admit the passage of air between it and the valve seat. This causes a disturbance of the dust at that point, sufficient to loosen it up and blow part of it into the zone affected by the ejector. The pipes *H* were placed in the corners of the hopper terminating in nozzles and attached to the high-air pressure for the purpose of blowing down through the region between the hopper bottom and ejector, and thereby breaking up any arch formations that might occur.

The dust thus extracted from the hopper is carried through the pipe *G* to the so-called carburetor, which is the mixing chamber. In this chamber the coal dust is mixed with the air required for its combustion.

The carburetor proper consists of a cylindrical metal vessel *I* with an interior perforated cylinder *J* which are joined at the discharge end. The volume air comes through pipe *K*, passes around the inner cylinder *J* and enters it through the ports *L*. The coal-carrying pipe *G* enters the end of the inner cylinder *J* a short distance, so that the coal dust in suspension is discharged into this cylinder. To supply any additional air that may be required, there is a conical valve and seat, the valve sliding on the end of the dust-carrying pipe *G* and the seat attached to the right-hand end of the inner cylinder *J*. This valve is actuated by a handwheel *M*.

Merely a Mixing Device

This is the "Pruden coal carburetor" and serves the same purpose as probably half a dozen other mixing devices in successful operation. It is purely a device for producing a diffusion of dust in the volume air. So far as it is apparent, this device is satisfactory and successful in accomplishing this purpose, although there is not even a remote resemblance to anything which is exclusive in producing such a mixing effect.

This equipment was conceived and developed about the first of 1916. It has never to our knowledge been applied to any furnace other than that shown, nor been used in connection with any commercial process whatsoever. It is not evident how the burning of dust in the furnace illustrated proves anything not already known for half a century.

The entire article is written in extravagant language, full of misleading generalities and implied thoughts which are intended to impress the reader with the idea of the possession of exclusive control of a fundamental principle. The conclusion is an appeal for the immediate investment in the stock of the company, advising that, like all things of this nature, the stock will advance almost immediately, and winding up with a recommendation by the Power-Wall Co., which is underwriting the securities, and which is perhaps most vitally interested in the sale of the stock. In view of the fact that the very service set forth as the exclusive possession of the company has been provided by numerous other concerns for a number of years, the absurdity and falsity of the claims of the company become conspicuously apparent.

Power can only regret that such an enterprise should have been undertaken, and publishes this article in the firm belief of its right and duty to set forth the facts and to counteract to the greatest extent it can, the influence of the advertising which has herein been quoted.

Electric Station Costs

To those who are used to thinking of steam engines as worth between $15 and $20 per horsepower and of slow-speed electric generators adapted for direct connection to such engines as half as much more per kilowatt, making a total of between $30 and $50 per kilowatt for the unit, the prices of $11 and $12 per kilowatt for turbine-driven generating units, mentioned by R. J. S. Pigott in the recent hearing before the Massachusetts Gas and Electric Light Commission, is an astonishing demonstration of the economies of aggregation and of doing things at high speed. He claimed that the Commonwealth Edison Co., of Chicago, had purchased 7500-kw. turbine sets at $87,500 each, and a 12,000-kw. unit for $140,000, which is between $11.50 and $12 per kilowatt. Overfeed stokers, Mr. Pigott said, require one stoker operator and one coal passer for about every five stokers, and underfeeds require one coal passer and one stoker for every 12 stokers. The Interborough Fifty-Ninth Street Station cost $150 per kilowatt originally, but the addition of low-pressure turbines brought this cost down to $87.50. The unit cost to the Edison Electric Illuminating Co., of Boston, of eight B. & W. boilers in 1903 was $12.53 per hp. against $11.50 for similar contracts on the same-sized boilers to other companies on or about the same date. Mr. Pigott's estimate of the cost of an 81,000-kw. station capable of handling the Boston Edison load, with the necessary reserve, was $65.60 per kw., exclusive of coal-storage facilities outside the plant. The generating cost at L Street for the year ending Nov. 30, 1914, was 0.48c. per kw.-hr., the ratio of coal cost to the total cost being about 75 per cent. The use of underfeed instead of overfeed stokers would, in the opinion of the witness, have increased this ratio to 80 per cent. and reduced the coal cost from 10 to 12 per cent. The cost at the Fifty-Ninth Street Station of the Interborough Rapid Transit Co. for the three years preceding the change from engine-driven units to combination engines and low-pressure turbines was 0.49c.

Hydro-Electric Plant Solves Water Problem

By Robert H. Moulton

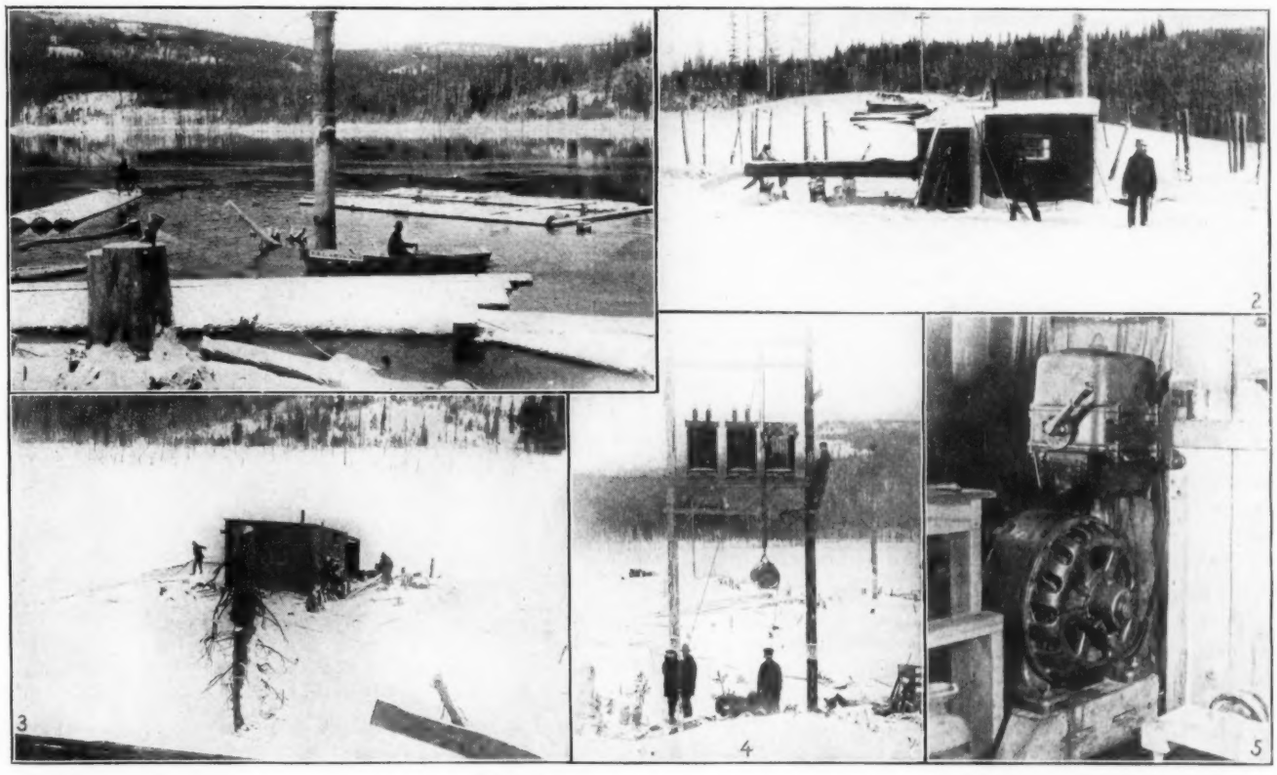
SYNOPSIS—Water of a reservoir became insufficient to supply a hydro-electric plant. An expenditure of 50 hp. in energy supplied sufficient water to operate the plant at its full capacity of 1500 hp

Inasmuch as hydro-electric plants depend for operation upon the force exerted by running water, it is natural to assume that if the supply of water gives out, the plant itself is put out of business. But a little thing like this does not bother the Eastern Oregon Light and Power Co., of Baker, Ore. True, the company has not solved the problem of running its plant without water, but it has found a way to make use of a water supply that really was at hand all the time, but which, heretofore, might as well have been a thousand miles away.

Up in the Blue Mountains of Grant County, Oregon, the company owns a small body of water, Olive Lake, which forms the principal storage reservoir for the operation of its 1500-kw. hydro-electric plant. The lake is at an elevation of 5970 ft. and the plant 4890 ft., a pipe line 5 miles long connecting the two. The lake covers an area of some 200 acres, with a depth of 50 ft., and apparently occupies the crater of an extinct volcano.

Mountain streams that are gushing torrents for a few months in the spring, but diminish to almost nothing during the rest of the year, feed the lake. To catch and store this surplus water a dam 34 ft. high has been constructed at one end of the lake. This 34 ft. when filled with the run-off snow water comprises the normal storage water for the operation of the plant, and under ordinary conditions has been found sufficient for all purposes. Last year, however, an extra drain was put upon it by reason of the destruction by fire of another plant, and in the fall it became apparent that, unless augmented in some manner, this stored water would be exhausted before the spring freshets came.

It then occurred to the superintendent of the company that a way might be found to utilize some of the original water of the lake, and the manner in which he succeeded in doing this was unusual.



FIGS. 1 TO 5. VIEWS OF THE LOG RAFT AND ELECTRICAL APPARATUS

Fig. 1—Assembling logs for the raft. Fig. 2—Raft and pumphouse. Fig. 3—Pushing raft to middle of lake. Fig. 4—Transformer being put in place. Fig. 5—Motor for driving one of the pumps

First a 40-ft. log raft was constructed and pushed through the ice and snow to the center of the lake. On the raft were placed two centrifugal pumps, each capable of lifting 4500 gal. of water per minute, power for working them being obtained by tapping a transmission line passing within a mile of the lake. Two pipe lines, with rubber sleeves to make them flexible, were then laid on pontoons and ice from the pumps to the intake of the main power-pipe line.

By means of this ingenious arrangement, and at an expenditure of only 50 hp. per day for operating the pumps, the necessary quantity of water for operating the generating plant and producing its full capacity of approximately 1500 hp. was easily and steadily maintained from December until April, when the melting snows again filled the reservoir.

Water in the Ammonia Charge

By E. W. Miller

SYNOPSIS—Water from the oil filter gets into the ammonia system through the lubricating piping, reducing the capacity and giving serious stuffing-box packing trouble.

The capacity of a small refrigeration plant had been gradually falling off until it was less than three-fourths of what it had been the summer before, although the machines had been speeded up several revolutions faster than they had been running, when I was called in to see if I could diagnose the cause of the trouble. The operators were unable to get the suction pressure above 12 to 15 lb., whereas the previous year they had maintained a pressure of 20 to 25 lb. They were also having considerable trouble with the stuffing-boxes of the two machines, which were of the horizontal type. Also at times, the machines knocked badly, as though they were getting liquid, although the discharge pipe would be hot and the frost line on the suction side of the machine showed no indications of change, as it generally does when liquid comes back with the suction gas.

Liquid Receiver Was Full

At first I thought that the plant was running with a short charge of ammonia. I was rather surprised to find the liquid receiver full. The chief informed me that the liquid level in the receiver had been gradually going up all summer until in the last two weeks it had kept entirely full all the time. This was so unusual that I could hardly believe it. I found the expansion valves were over a turn open; considering conditions, about half a turn should have been sufficient. The frost line that is always found on an expansion valve that is working properly was not sharp. The valve was lightly frosted, but the point where the frost started was not up on the body of the valve where it is usually found, but near where it was flanged and connected to the line leading to the expansion coil. This would indicate that the system was short of ammonia; but the receiver was full of liquid.

When we got back to the engine room the oiler was at work loosening up one of the stuffing-boxes, which was smoking. The chief said that he was having a serious time with these, as they would either leak so that no one could stay in the place or they would run hot and smoke after the packing was a few days old. Consequently they had to renew the packing about once a week.

Investigated Oiling System

After feeling of the rods, which seemed to me to be dry, I began to investigate the oiling system. The oil was supplied to the rods by gravity from a reservoir located high up on the wall of the engine room, a system by the way that is found in many plants. I was astonished by the color of the oil in the gage glass of the oil reservoir or tank. It looked like water. The chief told me that he filtered all the oil that was blown from the oil traps on the discharge lines of the compressors, and when this was insufficient they would put in new oil. I asked him if the filtered oil was anything like the color of that in the oil reservoir. He glanced at it and informed me that that was not oil but liquid ammonia. I expressed wonder at how he managed to keep ammonia liquid at 12 lb. pressure and the temperature of the engine room, which was about 90 deg. He had never thought of that!

On trying to get a sample of the oil we found that there was little, if any, oil in the tank. I told the chief that water was getting in the oil, and that likely it was coming from the filter.

The plant was a combination power, light and ice plant. The ammonia oil filter was stuck into an out-of-the-way hole between the foundations of two of the engines. The oil, after leaving the filter, was piped to a storage tank, from which it was pumped to the oil reservoir on the engine-room wall by a small pump.

Here I found the trouble. The storage tank was a home-made one of sheet iron. It was about 3 ft. wide by 6 ft. long and about 2 ft. high. The sides and ends had been extended above the top of the tank, to strengthen it most likely, forming a pan on the top about an inch high. The top was provided with a cover at one end. During the early spring a new dry-vacuum pump had been installed, and the discharge from this was into the basement, directly above the storage tank. All the moisture that was discharged with the air from the pump landed on top of the storage tank, the water running off so that it leaked into the oil tank of the filter. In addition a water line running above the tank had sprung a leak in a union directly above and all this was going directly into the tank. The water in the bottom of the storage tank was pumped to the engine-room tank before the oil level would drop low enough for the pump to get oil. There was also provided an oil connection to the suction of each compressor in addition to the stuffing-box connection, and they were in the habit of periodically giving the compressors a dose through this line. The whole ammonia system was charged with water, and the cause of the receiver gradually filling, the reason the back pressure went down and why the capacity fell off were all explained.

There was only one thing to do, and that was to get all the old ammonia out and a clean charge in. The ammonia oil filter was discontinued and only new oil used, and very little of that, and for the rods only. The oil that came from the oil traps was thrown into the oiling-system filter and used in the oiling system.

Taxation of Power Companies—The fact that 85 per cent of a power company's transmission lines are within the State of Nevada does not warrant an assessment against the company at the same percentage of the taxable value of the corporation's property, as ascertained by capitalizing its net earnings, where the most valuable part of the company's property is located in California. (United States District Court, District of Nevada; Nevada-California Power Co. vs. Hamilton; 235 "Federal Reporter," 317.)

Nonstop Turbine Run—The 25,000-kw. Parsons turbo-generator in the Fisk Street Station of the Commonwealth Edison Co. was recently shut down after 77 consecutive days' continuous operation upon the system without interruption. During this time the unit generated 27,589,730 kw.-hr., which is equivalent to an average of 14,930 kw. per hr. during the run. The high-load factor over such an extended period emphasizes the economy that can be obtained by these large generating units in the modern power plant of a central station company.

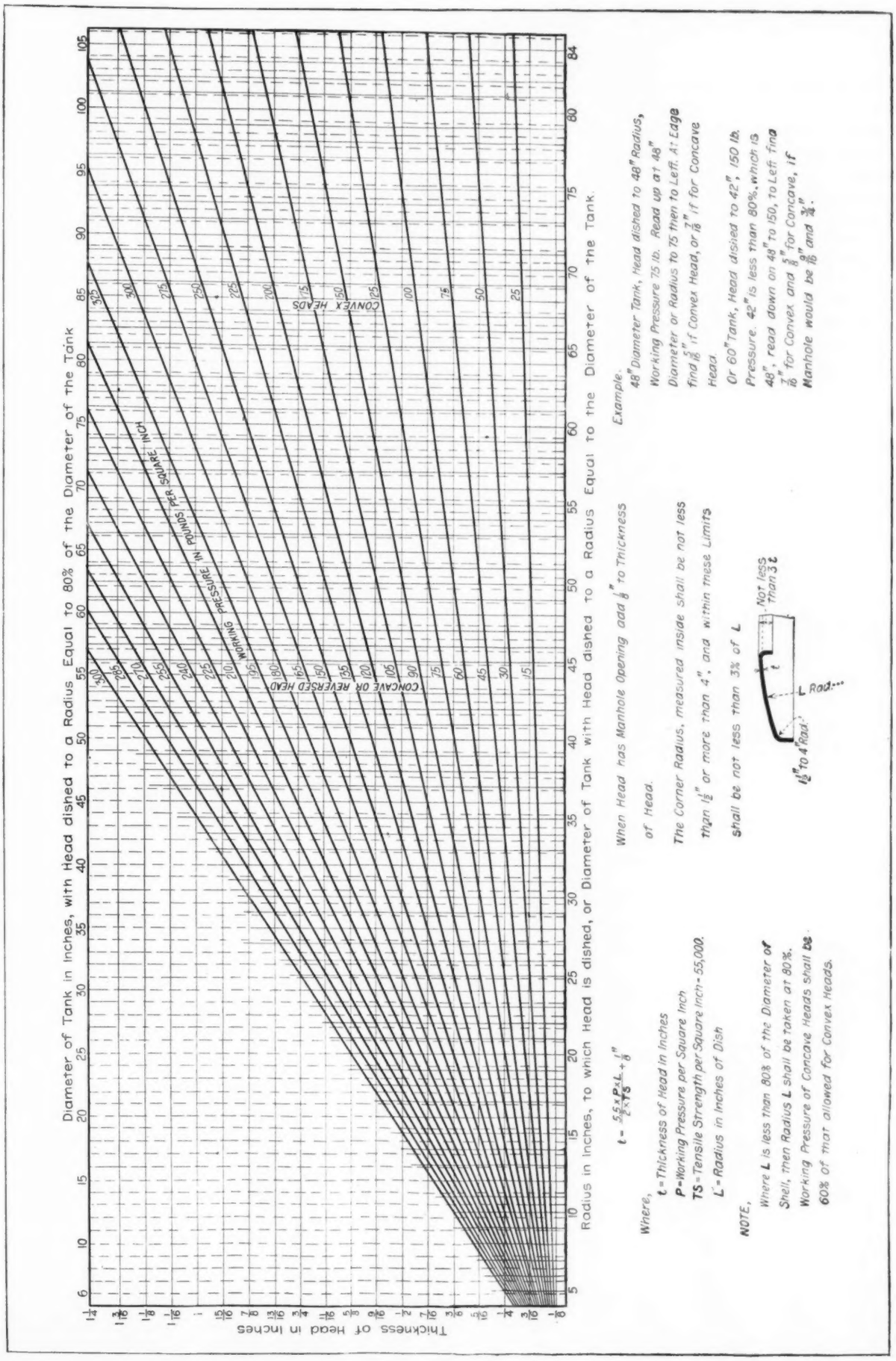

Diameter of Tank in Inches, with Head dished to a Radius Equal to 80% of the Diameter of the Tank
Radius in Inches, to which Head is dished, or Diameter of Tank with Head dished to a Radius Equal to the Diameter of the Tank.
Thickness of Head in Inches
CONCAVE OR REVERSED HEAD
CONVEX HEADS
WORKING PRESSURE IN POUNDS PER SQUARE INCH
$t = \frac{5.5 \times P \times L}{2 \times TS} + \frac{1}{8}$"
Where,
t = Thickness of Head in Inches
P = Working Pressure per Square Inch
TS = Tensile Strength per Square Inch = 55,000.
L = Radius in Inches of Dish
NOTE,
Where L is less than 80% of the Diameter of Shell, then Radius L shall be taken at 80%.
Working Pressure of Concave Heads shall be 60% of that allowed for Convex Heads.
When Head has Manhole Opening add $\frac{1}{8}$" to Thickness of Head.
The Corner Radius, measured inside Shall be not less than $1\frac{1}{2}$" or more than 4", and within these Limits shall be not less than 3% of L
Not less than 3t
t
L Radius
$1\frac{1}{2}$" to 4" Rad.
Example:
48" Diameter Tank, Head dished to 48" Radius, Working Pressure 75 lb. Read up at 48" Diameter or Radius to 75 then to Left. At Edge find $\frac{5}{16}$" If Convex Head, or $\frac{7}{16}$" If for Concave Head
Or 60" Tank, Head dished to 42", 150 lb. Pressure. 42" is less than 80%, which is 48", read down on 48" to 150, To Left find $\frac{7}{16}$" for Convex and $\frac{5}{8}$" for Concave, If Manhole would be $\frac{9}{16}$ and $\frac{3}{4}$".

DIAGRAM FOR FIGURING DIMENSIONS OF DISHED HEADS

Worked out by E. W. Ashenden, mechanical engineer for the William Brothers Boiler and Manufacturing Co., of Minneapolis, from formula in the A. S. M. E. Boiler Code

Steam-Engine Troubles—Releasing Gears

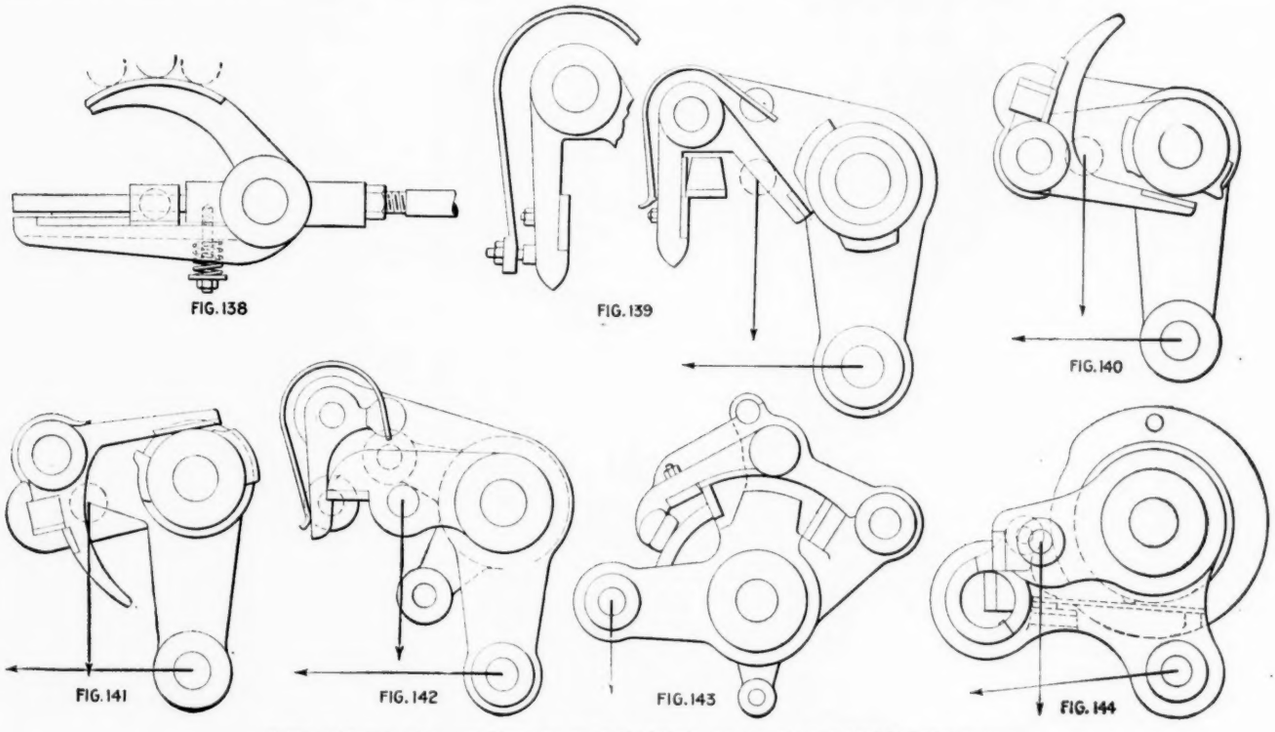
By H. Hamkens

SYNOPSIS—Forms of crab claws. Hooks of radial valve gears should have the pinhole bushed to care for wear. Why catch plates wear rapidly. With radial gears designers aim to bring all strains as nearly as possible in the same plane and do away with curved springs. This is the tenth article of the series.

The old crab claw, Fig. 138, is disappearing. It has done good service on slow-speed engines running with a steady load and using low steam pressures. The trouble with it is that the catch plates and pins are subject to excessive wear, which makes it expensive to keep in repair. On account of its weight the crab claw is liable to miss hooking on. The leverage on the curved arm changes for different cutoffs, as indicated in dotted lines in the sketch, throwing a variable strain on the governor.

The radial valve gear, Fig. 139, originated by Edwin Reynolds has some decided advantages over the crab-claw gear, although it, too, is becoming obsolete. The hook used to be made of bronze and was liable to break; the hole for the pin wore out of round, making the valve gear noisy and unreliable. The hook should therefore be made of forged steel, and the hole should have a bronze bushing that can be replaced when worn. The curved spring is troublesome, for it is almost impossible to make two springs of this kind alike in shape and temper; some of them will last a lifetime, others break after a short while. If they are too stiff, they will throw a greater strain on the governor, and if too weak, the catch plates will slip and wear off rapidly until they will not pick up. It is common practice to push a piece of leather under the spring and exert more pressure on the hook and to change the catch plates as soon as the engine can be shut down. A spring adjustable by a setscrew at the extreme end which bears against the hook, as shown in detail, is being used. This may or may not be an improvement; it depends on the pressure put on the hook. If the engineer does not use good judgment, but tries to make sure of hooking up even if the catch plates are worn a little and exerts all the pressure the spring will stand, the shock on the governor to release the hook will be excessive and the strain on the valve gear much increased. As the toe plate on the trip lever of the hook wears, the engine will take more steam for the same position of the governor and its speed will increase. This should be watched for and the plates be changed to another edge when the wear becomes noticeable. A piece of leather on the hook is often used to control the lap of the catch plates, but it will wear by hammering on the hook and should be renewed from time to time.

Notwithstanding its shortcomings, the Reynolds radial gear has been copied by many engine builders and modified by some; in fact nearly all Corliss releasing gears are based on the radial principle. The designer of the arrangement shown in Fig. 140 got himself into trouble by locating the hook on the steam arm with the dashpot rod. The hook block is fastened in the steam bell crank, the hook is reversed and the action is the opposite to that of the Reynolds gear. On higher speeds and variable loads the design was found to be defective. The hook would shake loose on its pin and fail in picking up, owing to the inertia of the trip lever. So the hook was changed to the position shown in Fig. 141,



FIGS. 138 TO 144. TYPES OF RELEASING GEAR FOR CORLISS ENGINES

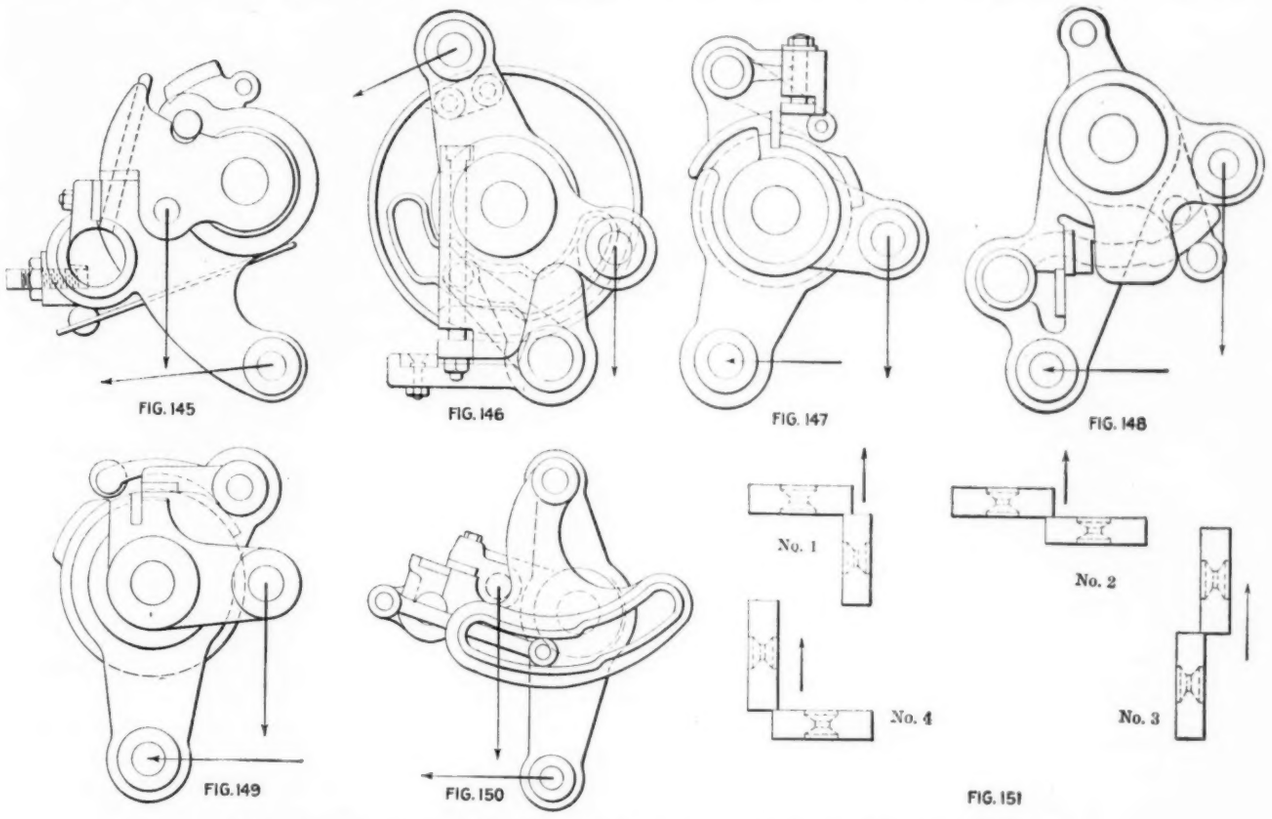
which corrected the trouble. The pickup takes place on the inside of the hook block, and the inertia of the trip lever assists in hooking up.

An improvement on the original radial gear is shown in Fig. 142. One of the catch plates is supported directly on the under side of the steam arm, without the use of a hook block. This throws the strain in direct line with the arm, without any lever action as on the gears just described. Overhung pins and hook blocks are likely to become troublesome, since the strains act on a leverage instead of in a straight line. The consequence is that the parts wear out, especially the catch plates, requiring frequent change of cutting edges and renewal. The hook in Fig. 142 is bolted to a rockshaft which rotates in a long bearing in one arm of the steam bell crank and carries at the other end a trip lever with a roller. The knockoff lever is provided with rollers instead of cams, as on the Reynolds gear. The only objection to this design is the curved spring.

Fig. 143 shows a simplified hook with an extension on one side near the end, which acts as a trip lever. In tripping a side strain is thrown on the hook, which will wear the hole out of round. The hook acts partly by gravity; a light spring is also used to prevent the catch plate slipping at high speed. The extension on the hook carries a piece of fiber which rides on the knockoff lever and trips the valve gear. This is a doubtful improvement; it makes the valve gear almost noiseless, but shows considerable wear after a short time. With a little care this valve gear will give good service for a long time.

The aim of valve-gear designers is to bring all strains as nearly as possible in the same plane and to do away with curved springs. Fig. 144 shows the first successful gear of this kind, which is still much used. There is no hook, and the end of the rockshaft is simply milled out to receive the catch plate. The latter engages its mate, which is screwed to the outer end of the steam arm. Both plates are placed in a vertical position instead of one horizontally and the other vertically. This has its advantage, as will be explained later. With the catch plate on the extreme end of the steam arm, the dashpot pin can be moved out, thereby increasing the lift of the pot and the leverage of the arm, making it more effective, especially for double-ported valves and high steam pressures. There is no appreciable wear of the rockshaft; even after years of service it will remain in excellent condition if the oiling is attended to, because it has full support under the catch plate where the greatest strain is applied. The trip lever at the other end of the rockshaft is provided with a roller that strikes a cam on the knockoff lever. The weak point of this valve gear is the insignificant straight spring that is forced in between two fixed points on the steam bell crank and a lug on the knockoff lever. A heavy initial strain is put on the spring, and as its working length is short it will soon break. A supply of these springs must be kept on hand; if one breaks, a new one can be slipped in place without stopping the engine, and even two, one on top of the other, may be used if one is not strong enough. The roller at the end of the knockoff lever makes this valve gear somewhat noisy when it is run at high speeds.

Fig. 145 shows a similar design, but instead of extending the rockshaft bearing to the outer edge of the lever carrying the catch plate, it is increased in diameter and provided with an adjusting screw by which the lap of the catch plates can be regulated to any desired



FIGS. 145 TO 151. OTHER MORE ELABORATE TYPES OF RELEASING GEAR

degree. If the edges wear a little, the lap can be increased, which is often a great convenience. There are no leathers used for regulating the pick-up. A substantial straight spring, not subject to frequent breaking, makes the valve gear hook up, and a straight trip lever effects the release by striking a fiber block. On this valve gear the steam arm is supported and bears in the bonnet. This is unusual. It has the good effect that the valve stem is relieved of all transverse strain and wear at the outer end. The leverage of the dashpot rod pin is short, therefore it requires powerful dashpots to close the steam valves tightly. On light loads and with high steam pressures the pots will stick, causing the valve gear to rattle disagreeably. If the catch plate on the steam arm should be placed vertically, as in Fig. 144, the pin for the dashpot rod could be moved out considerably and the trouble overcome.

Valve-Gear Catch Plates

Curved or straight springs used on trip motions give more or less trouble and should be avoided if possible. Fig. 146 shows a design which engages the catch plates by gravity and accomplishes the knockoff by a cam and roller without the use of a spring. One of the catch plates is fastened to a long bolt with a sliding motion in the steam arm. For high speeds this gear does not seem to be suitable. The heavy bolt and plate make its action sluggish; besides, the hardened block wears a shoulder on the steam arm and this in the course of time will impair its action.

A modification of this gear is shown in Fig. 147. The catch plates are transferred from below to above the steam arm, the sliding bolt is made shorter and lighter and cutoff is effected by a trip lever with a roller. The catch plates engage by gravity. There is an auxiliary light spring provided to accelerate the motion of the sliding bolt, but this is found to be necessary only on high speeds. The appearance of the whole design is pleasing, but the short sliding bolts give trouble after a short while and the action becomes uncertain. The catch plates fail to engage occasionally, with the result that the steam valve does not open.

The design shown in Fig. 148 is rather complicated, but no spring is used and the latch and lever carrying the catch plates are well supported. The trip lever is connected to a flat steel arm having two cam surfaces milled on the high sides, the motion of which is controlled by two rollers on the knockoff lever. The action seems to be quite positive and satisfactory. The rollers will become noisy after considerable service, especially on higher speeds.

A Serviceable Gear

In Fig. 149 the trip arm, trip lever and rockshaft are located on the top of the steam bell crank and arm. There are no springs, delicate cam levers or slotted plates used, which will wear out and are expensive; everything works by gravity. The rockshaft has a long bearing in the bell crank and the knockoff cams and safety cams are easily replaced if worn. This valve gear will give good service if properly attended to.

The valve gear shown in Fig. 150 differs from the others in its method of tripping the catch plates by a separate motion imparted to a slotted knockoff lever. The motion is derived from an eccentric on the main shaft and is carried through a rocker arm on the governor to the valve gear. There are numerous levers, pins, links and rollers employed, which, of course, will wear out, make the gear noisy, require a lot of lubrication and attention and become generally troublesome. The inertia due to the oscillation of the knockoff levers and connections is a disturbing factor. As all the pins and rollers of this trip motion must be hardened and ground and the pivots for the governor connections are hardened and have to run in hardened tool-steel bushings, trouble may be expected. For American practice, where simplicity, reliability, durability and ease of repairs are of paramount importance, this valve gear can hardly be recommended. The claim that it is superior to other long-range gears on account of using only one wristplate while others use two can hardly be substantiated at the present time, since some of the best Corliss engines installed have no wristplate at all.

Position of Catch Plates

Naturally, the parts that are subject to the greatest shocks and wear on a valve gear are the two catch plates, which engage on a narrow edge every time the valve gear hooks up. On new engines where the steam valves have not yet come to a proper seat, these plates are often overstrained and break off at the edges. New valves are likely to work hard, unless well lubricated. The plates must be made of high-carbon steel, well tempered. In Fig. 151 the prevailing positions of the plates in regard to one another are shown. In No. 1 the edge of a high side engages an edge of a flat side; in No. 2 the edges of two flat sides come in contact; in No. 3 those of two high sides, and in No. 4 of a flat side against a high side. Although it is claimed for high-carbon steel that it has no grain and offers the same resistance per unit of area in any direction, it is evident from the way most of it is hammered out into long bars that if there is any fiber or grain it must run lengthwise in the bar, and that the material will offer greater resistance to shock in this direction than in any other. Of the four different positions in Fig. 151, therefore, No. 3 should be the most advantageous for the plates. Experience seems to bear this out. There is, among others, a case on record where two catch plates in this position have been working for over 10 years at 120 r.p.m., 6 to 8 hours a day, 6 days a week, without changing the wearing surfaces. The plates are in the same position as when the engine was started, showing a smooth, sharp edge without any wear. The steam pressure carried on the boilers is 120 lb. This performance has probably never been equaled.

The catch plates should be made square to make eight wearing surfaces available by changing their position. The edges are often broken by allowing too much space between them in hooking up; the closer they come together the lighter will be the shock and the longer they will last. For a nice-running valve gear the distance should not be more than $\frac{1}{16}$ in., and the depth to which the two plates engage should also not exceed $\frac{1}{16}$ in., or $\frac{3}{32}$ in. at the most: if they have to engage deeper to catch, something is wrong.

[*The next article treats of various designs of wristplates.*]

Complex Steel is an alloy steel containing more than two allowing elements, such as high-speed tool steel.

Visits of Inspector Brown—XXIII

By J. E. Terman

SYNOPSIS—The Chief shows Brown how to diagram the formula for the bursting pressure of cylinders, assuming a tensile strength of 55,000 lb. When the diagram is finished and the method of constructing it has been explained, Brown thinks it is just the thing and is surprised when the Chief tells him that another one, of real value relating to bursting pressures, can be made.

"The last time we talked about plotting formulas, Brown, you were to diagram the formula giving the bursting pressures of solid cylinders," said the Chief, as Brown came into his office a few days after their last conversation.

"That is so, Chief, but the fact of the matter is that I have been too busy to think about it."

"Well, that is a good excuse," said the Chief, "and I will show you how it is to be done. The diagram we will make will give the bursting pressures where the tensile strength is 55,000 lb., since that is the tensile strength you are most concerned with; in fact, it is the one you probably use 90 per cent. of the time. We will take a sheet of prepared cross-section paper" (see illustration), "and from the formula giving the bursting pressure of a cylinder,

$$\textit{Bursting pressure} = \frac{TS \times t}{r} \qquad (1)$$

it is evident that all the lines representing the different values of r will pass through the origin O, at the intersection of the axes of x and y, for you will remember that with TS and r representing constant values, this formula would be of the form $y = ax$, so we will represent the bursting pressures on the axis of y in pounds per square inch and the thicknesses on the axis of x in sixteenths of an inch."

"Say, Chief, can't you take a wider piece of paper and make that scale of thicknesses larger? I want that diagram for use, because it will be a whole lot of help to me."

"No, Brown, we need not make this diagram larger or very accurate, for I want it only to show you how such a diagram may be made. Before we complete the subject of making a diagram for the bursting pressures of cylinders, I will show you how its usefulness may be extended and then we will make a really serviceable diagram.

"Starting with a cylinder having a radius of 9 in., which is about the smallest with which you are likely to deal, and making a 3-in. increase in the radius for each succeeding size, this diagram will be arranged to include all radii from 9 to 36 in. First, we will obtain the point on the ⅛-in. plate thickness line where the line representing the 9-in. radius intersects it, this intersection being secured directly from this formula (1) by substituting 55,000 for TS, 9 in. for r and ⅛ in. for t; thus, $BP = \frac{55{,}000 \times \frac{1}{8}}{9} = 764$ lb. I have placed the dot at A in the figure to indicate the position of the point representing a bursting pressure of 764 lb. The reason that I selected the ⅛-in. plate thickness line was because the range of bursting pressures for the diagram would not permit a larger plate thickness to be chosen and have the point fall within the range of the diagram. Next, we will find the point on the $\frac{7}{16}$-in. plate thickness line where the line representing a 36-in. radius intersects it, and this is done by substituting in the formula $\frac{7}{16}$ for t and 36 for r; thus, $BP = \frac{55{,}000 \times \frac{7}{16}}{36} = 668$ lb. This intersection I have marked B.

"Next, we will draw a line through A and O and one through B and O, and these two lines will give the bursting pressures for seamless cylinders made of 55,000 tensilestrength plate where the diameters are 18 and 72 in. respectively. The reason that I have given the diameters rather than the radii is because it is usual for us inspectors to think of the size of cylinders in diameters rather than in radii. This change, of course, does not affect the diagram, for it is evident that the bursting pressure of a cylinder with a 9-in. radius must be the same as for one of 18-in. diameter where the plate thickness is the same."

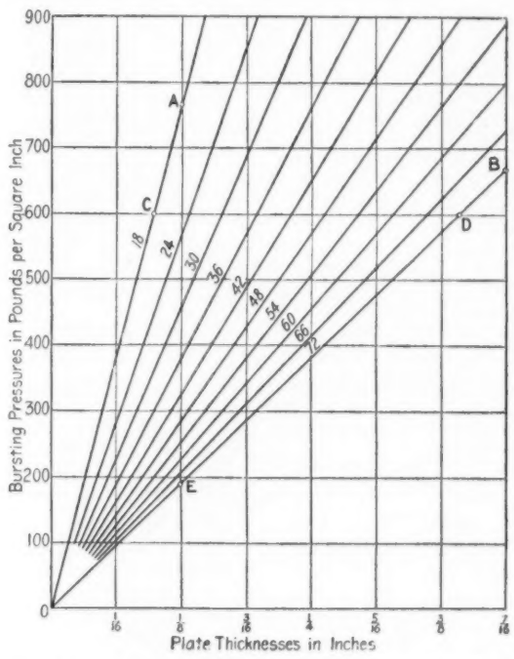


DIAGRAM FOR BOILER-BURSTING PRESSURE

"Yes, Chief, I can see that readily enough," said Brown, "but what I don't see is, if the value of r in the formula is changed to the value of the diameter, why the equation will not be changed."

"Why, it would be, Brown; but if you use the diameter in the formula instead of the radius, then you would be dealing with the thickness of the shell plate on both sides of the cylinder, and the value of t would be required to be doubled, which would just counteract the doubling of the value of r."

"Why, sure it would, Chief; I don't know why I didn't see that."

"You will remember, Brown, that when we made the diagram of the multiplication table, I called your attention to the fact that the intersections of the diagonal lines

representing multiplicands on any of the vertical lines representing multipliers were equal distances apart. Therefore, if two points were found on one of the vertical lines, the points of intersection of the lines representing intermediate values on this same vertical line could be obtained by dividing into even spaces the distance between the first two points. In the formula $BP = \left(\frac{TS}{r}\right) \times t$ you can see that the value of $\frac{TS}{r}$, which is constant for each line of the diagram, does not increase by equal increments from line to line, for while the values of r are increased by the constant increment of 3 in., the value of the whole fraction is variable and the space between A and E on the ⅛-in. line would not be divided into equal spaces by the lines representing intermediate values of r, or diameters, as we have decided to take. Therefore, even vertical spaces, as used in the diagram of the multiplication table, cannot be used."

"Well, Chief, all that I can see to do is to figure a point for each one of the diagonal lines separately; and that is certainly easy enough, for think how many values for bursting pressures will be obtained by the intersections on each one of those lines."

"Now, Brown, that is not the way to attack a problem of this kind. You must not give up so easily, for it usually pays to spend a lot of time in trying to shorten the work of making a diagram. If you spend more time in finding a short-cut than would be required to make the diagram by some longer method, you will still make a gain if you eventually find a short-cut, because you can use the experience in making some other diagram. Now, in this case our formula is

$$BP = \frac{TS}{r} \times t$$

and by transposition it becomes

$$BP \times \left(\frac{r}{TS}\right) = t \qquad (2)$$

It is easy to see, since TS is constant, that with equal variations in the value of r for the different lines of the diagram the distance between the lines on a horizontal line will be equal; that is, the distance from C to D is to be divided into equal spaces to obtain the intersections for the intermediate lines between AO and BO. If you don't see this clearly, Brown, let me put it up to you in this way: In formula (2) assume BP and TS to have constant values, and r and t to have variable values. Then if we represent the constant value of $\frac{BP}{TS}$ by G, the formula becomes $G \times r = t$; and if r increases in equal steps, then the values of t corresponding to these increases in r would be in equal steps. Therefore, the distance between C and D on this diagram would be divided into equal spaces by the various lines representing the values of r."

"Well, Chief, there seems to be no end to the different combinations that may be worked or the twisting of formulas that may be undertaken in arriving at a simple method of diagraming the values derived from a given formula."

"A little study will always help matters, Brown," said the Chief, "and sometimes it takes quite a lot of study; but you should never give up until you are convinced that you have reached the simplest solution that may be applied to the problem in hand—diagraming a formula. In the case of the diagram we are drawing," continued the Chief, "all that remains to be done is to divide the distance between C and D into nine equal parts, denoting the divisions by dots and drawing through each of these dots a straight line to the intersection of the axes of x and y. The diagonal lines thus drawn give the bursting pressures for all the intermediate diameters between 18 and 72 in., by 6-in. increments for diameter. I guess you will find this diagram pretty accurate if you care to check it up, Brown."

"I know that it is, Chief, for while you were drawing those diagonal lines I have looked over the different values that I have found wrong in the table that I copied from Jones, and I see that the diagram gives the proper value in each case. I certainly feel like a chump, Chief, to think how hard I have worked at times to check up Jones' table of bursting pressures and add to it, when there was such a simple way to obtain all the values that I would have required."

"No, Brown, you need not feel that the time you put in on those calculations was entirely wasted, for you will be more likely to remember about this shorter method of getting the values by means of a diagram, after having experienced the labor of deriving them by main strength and awkwardness. As it is getting rather late, we will have to stop our discussion for today; but if you will come in another afternoon, I will show how a diagram of bursting pressures can be made that will be really useful."

"I will certainly be in soon, Chief, for if you can get up a diagram to beat that one it must be a pippin."

War Department Forming Engineer Enlisted Reserve Corps

The members of the Engineer Officers Reserve Corps, United States Army, have been notified by the War Department that a large enrollment is desired of enlisted men in the Engineer Enlisted Reserve Corps, provided for in the National Defense Act of June 3, 1916. All the equipment, subsistence and transportation are furnished by the Government, during service. An annual training period of 15 days is required. Pay ranges from $75 to $15 per month. The following requirements are stated for the several grades in the pioneer regiments:

Master Engineer, Senior Grade—Required at times to take the place of officers and to take independent charge of construction in the field; must be specially qualified also as expert lithographer, photographer, draftsman, surveyor or construction superintendent. Two to each regiment.

Master Engineer, Junior Grade—Same qualifications as for master engineer, senior grade; must be specially qualified as foreman electrician and expert searchlight operator, foreman carpenter, construction foreman or foreman machinist and engineman. Three to each battalion.

Other Grades Above Sergeant—Grades include sergeant major, sergeant first class, and supply, color, bugler, first and stable sergeants. Same qualifications required as for sergeant; must be specially qualified as master carpenter, master mechanic, road foreman, expert in demolitions, blacksmith, rigger, boatman, topographer or draftsman. Seven per company.

Sergeant and Lower Grades—Qualifications ascertained by recruiting or recommending officer. Every enlisted man out of the 109 in a pioneer company must have some special qualification, distributed (two to four each) among the occupations already noted and also among quarrymen, miners, plumbers, firemen, masons, calkers, axmen, packers, teamsters, saddlers, cooks, clerks, musicians and signalmen, the greatest preponderance being of topographical surveyors and sketchers (9), quarrymen and miners (11), bridge carpenters (16), electricians (6), axmen (8), teamsters (10). Six sergeants and 12 corporals per company.

Steam Engineer's License Examination—V

By H. F. Gauss

SYNOPSIS—Problems showing the simplicity of the Zeuner valve diagram and the ease with which lap, lead, angle of advance and the various events of the stroke may be determined.

As an example of the application of the Zeuner valve diagram the following simple problem will be discussed:

Problem: Given the point of admission, the point of cutoff and travel of the valve; required the angle of advance, the steam lap and the steam lead. As in Fig. 1, draw a circle $A_1C_3AA_1$, with a radius equal to the eccentricity of the eccentric, or half the travel of the valve. Let a be the point of admission and C the point of cutoff. Neglecting the angularity of the connecting-rod, the corresponding crank positions at admission and cutoff may be found by drawing aC_1 and CC_2 perpendicular to A_1OA; OC_1 and OC_2 being the crank positions respectively. Since the points of admission and cutoff are determined by the intersections of the steam-displacement circle with the steam-lap circle, the crank position at maximum valve displacement will be halfway between these points. Bisect the arc C_1C_2, thus locating C_m. It will be evident that OC_m is the diameter of the steam-displacement circle and the crank position at maximum valve displacement. Draw the steam-displacement circle OC_m, intersecting OC_1 at E and OC_2 at F. Then OE is equal to OF and is the radius of the steam-lap circle BD. Angle C_mOC_3 is equal to the angle of advance. Lay off angle C_3OC_4 equal to the angle of advance and draw C_4G perpendicular to A_1OA. Then DG is the lead.

It is not necessary to make this separate construction to determine the lead; HB is the lead direct, since it is the distance intercepted on the crank between the steam-lap circle and the steam-displacement circle, with the engine at dead center. It should be borne in mind, however, that the angle C_mOC_3, while equal to the angle of advance, is laid off on the opposite side of the vertical OC_3.

The exhaust-lap circle may now be drawn and the exhaust displacement circle, thus determining the points of release and compression.

By means of the Zeuner valve diagram, having given any three of the following quantities, the remaining three may be found: (1) Angle of advance, (2) steam lap, (3) steam lead, (4) point of admission, (5) point of cutoff, (6) eccentricity, equal to half the travel of the valve.

It has been shown how, having given the point of admission, the point of cutoff and the travel of the valve, it was at once possible to find the angle of advance, the steam lap and the steam lead. As a second problem, suppose there are given the steam lap, the point of admission and the point of cutoff; required, the angle of advance, the steam lead and the eccentricity.

Fig. 2 gives the solution of the problem. Draw any circle of diameter A_1OA, which can be assumed to be the crank circle, the diameter being the stroke, on which, lay off the given points of admission and cutoff, a and C respectively. Neglecting the angularity of the connecting-rod, project a and C to the crank circle, thus locating OC_1, the crank position at admission, and OC_2, the crank position at cutoff. The crank position for maximum valve opening will evidently be midway between these two positions, and is at once determined by bisecting angle C_1OC_2. Then OC_m is the crank position at maximum valve opening, C_mOY being the angle of advance. As will be evident OY is drawn perpendicular to A_1OA. Draw the steam-lap circle with the center at O, and with a radius equal to the given lap. The steam-displacement circle must pass through B, at the point of intersection of the crank position at admission with the steam-lap circle. Then B is a point on the steam-displacement circle, the diameter of which must be on the line OC_m. Since an angle inscribed in a semicircle must be a right angle, if BM is drawn perpendicular to OB, the intersection of BM with OC_m is the extremity of the diameter of the steam-displacement circle. The displacement circle may now be drawn, and the lead DE is at once determined. The distance OM is the eccentricity of the eccentric.

The Zeuner valve diagram makes plain the fact that increasing the angle of advance causes cutoff to occur earlier in the stroke. If this were the only event affected

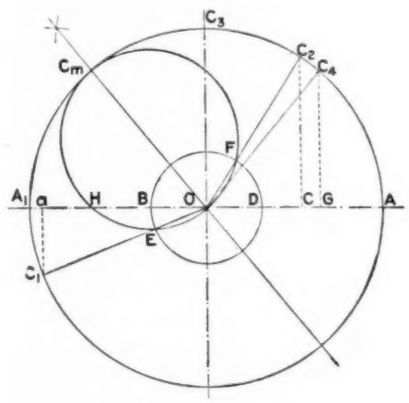


Fig. 1

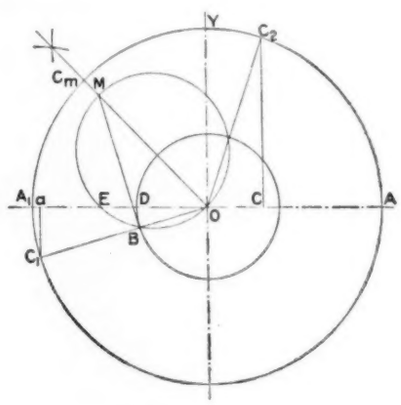


Fig. 2

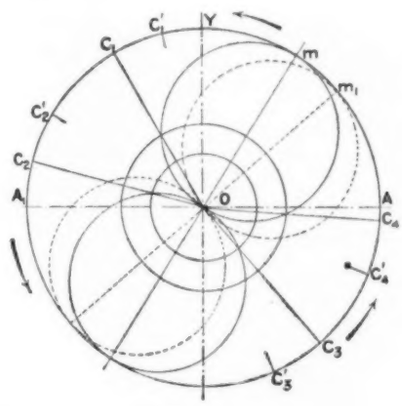


Fig. 3

FIGS. 1 TO 3. APPLICATION OF THE ZEUNER DIAGRAM TO THE DESIGN AND ADJUSTMENT OF VALVES

Fig. 1—Locating point of admission and cutoff. Fig. 2—Determining angle of advance, lead and eccentricity. Fig. 3—Diagram for a given engine or study

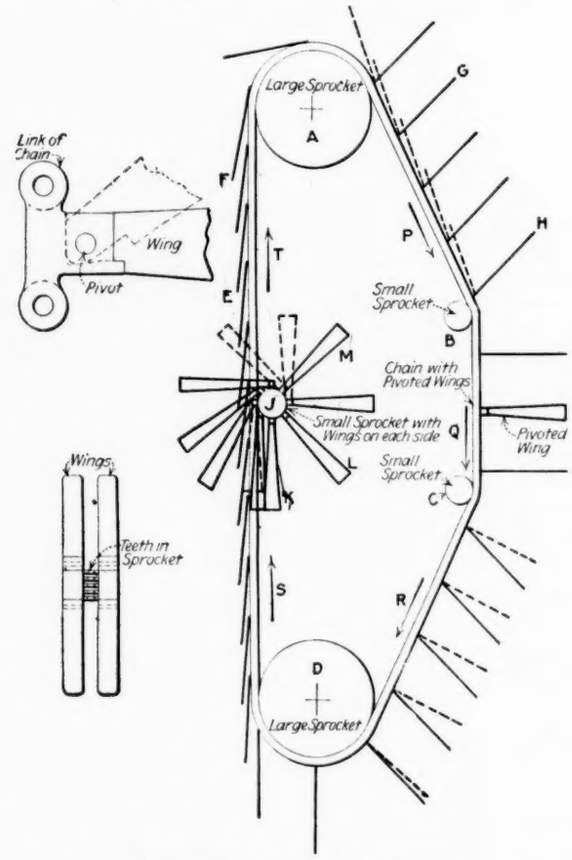
by varying the angle of advance, cutoff could be made to occur as early as desired. However, the diagram shows that increasing the angle of advance makes all events occur earlier in the stroke. Thus Fig. 3 shows a diagram for a certain engine. With the angle of advance mOY, cutoff occurs when the crank is in position OC_1, release occurs when the crank is in position OC_2, compression occurs when the crank is in position OC_3, and admission when the crank is at OC_4. Now, if the angle of advance is increased to m_1OY, these events occur at C'_1, C'_2, C'_3 and C'_4, all of which are earlier in the stroke.

Again by increasing the steam lap, cutoff can be made to occur earlier in the stroke. However, this involves changes in the other functions; for example, it makes a greater eccentricity necessary, requires a greater angle of advance, etc. Hence this method of securing an early cutoff with a common slide-valve engine is also limited.

After all has been done, cutoff cannot be made earlier than about seven-tenths stroke, and other means than increasing the steam lap and angle of advance must be resorted to. The cutoff or expansion valve commonly known as the Meyer expansion valve is a solution of this problem. It will be discussed in the next article.

Two More Perpetual-Motion Fallacies

Here is another of the schemes for getting something out of nothing. The full lines of the sketch are the same as a drawing that is being circulated of an invention that



PERPETUAL-MOTION FRAUD

will enable investors to "get rich quick." The dotted lines and letters have been added for reference. A sprocket chain with links, such as shown in the detail, is to be suspended over the large sprocket wheel A and passed over the small sprockets B and C and large sprocket D. At intervals the links carry weighted wings E, F, G, H, etc. A small sprocket wheel J that is in gear with the chain carries similar wings K, L, M, etc. The enthusiastic investor is told by the projector of the invention that the greater length of chain and weighted wings G, H, etc., will cause the right-hand side to fall continuously in the direction of the arrows P, Q and R, will raise the other side in the direction of the arrows S and T and incidentally turn the sprocket wheel J and develop enough power for a farmer to run his corn sheller or grindstone, and that it is only a question of size of a perpetual motor required for running a threshing machine.

The full lines G H are stated by the promoters to indicate the position that will be occupied by the pivoted wings lending leverage; but as a matter of fact, if the wings were pivoted as shown in the detail, they would assume the positions indicated by the dotted lines. The fallacy of perpetual motion, even without friction of the sprocket wheels, is easily understood by considering that the equilibrium would be practically the same as though the sprocket chain were only hung over pulleys at A and D without being passed around B and C, and there would be no greater tendency for one side of the system to pull up the other than for perpetual motion of an endless rope or chain suspended in the same manner.

One Jacob Raes, of Washington, D. C., is trying to raise capital to perfect and exploit what he calls a "spring motor," consisting, according to the Washington *Herald*, of a large spring wound up by means of a worm drive. Several cog gears drive a small dynamo at sufficient speed to generate enough electricity to drive a still smaller motor, which turns several wheels connected by cord belts.

For demonstrating purposes the inventor winds up the spring and releases the brake. The dynamo runs, power is generated, and the motor runs. Raes winds the spring as fast as it runs down. The arrangement, he says, will some day run all the automobiles, heat all the houses and furnish power to turn all the wheels of industry. "Then all the coal mines can be closed up," he explained. "Working but a few hours each day, people will be able to produce easily everything the country needs. Of course I must turn it with my hand, but when I get a larger dynamo, a larger motor and ball-bearing gears, it is bound to run itself.

"You see," he says, "when we eliminate this unnecessary friction and get a large enough apparatus, we will hook the motor up with this crank and let it wind up the spring, and as the spring runs down it will turn the dynamo, which will make the electricity, which will run the motor, which will continue to wind the spring."

"But where will you get the power for use?"

"That is easy. You see this extra cogwheel on this side? Well, we will just connect an extra dynamo on there when it gets to running and use the electricity it generates."

A Building Radiates Heat just as a radiator does. When the dissipation of heat by the radiators exceeds that given out by the building, the room temperature rises, and when the rate is less the room temperature drops. To maintain a constant temperature efficiently requires a medium that can be readily varied in temperature and an apparatus whose mass will absorb or equalize the heat from each temperature change.

Hydro-Electric Power in France

By A. R. Decker

The first rush of the German invasion deprived France of 80 per cent. of its metallurgic resources, 34 per cent. of its mechanical power and 70 per cent. of its coal supply. However, today we see France making 25 per cent. of its steel and the greater part of its explosives. This was made possible through an extraordinary development of hydro-electric power, through use of the "white coal" stored on the tops of the Alps, the Pyrénées and the central mountain ranges, and the "green coal" of the many rivers that spring from melting ice and snow.

In 1884 France boasted of only seven hydro-electric stations; in 1914, on the eve of the war, this number had increased to 1173, classified as follows, according to developed horsepower: Less than 25 hp., 429 stations; from 25 to 100 hp., 520; from 101 to 500 hp., 158; from 501 to 1000 hp., 18; from 1001 to 10,000 hp., 41; above 10,000 hp., 7.

Decreasing Coal Production

During 1915 France mined about 19,750,000 tons of coal, against 29,786,000 extracted in 1914 and 40,813,000 in 1913. The needs of the factories constantly increased so that it was necessary to import 15,430,000 tons of coal in 1914 and 19,067,000 tons in 1915. The purchase price has been exorbitant, demanding considerable gold exportation. So France has every incentive to develop its hydro-electric power for the purpose of replacing domestic or foreign coal. The importance of this is realized when it is considered that a fall of water developing 5000 hp. will generate in a year 32 million kilowatt-hours; for the same production 50,000 tons of coal would have to be burned.

The region of the Alps alone furnishes electric power throughout ten French departments, covering 22,000 sq.mi.: Upper Savoia, the Savoie, the Isère, the Drôme, the Upper Alps, the Lower Alps, Vaucluse, Mouths-of-the-Rhône, the Var and the Maritime Alps. Numerous companies exploit this power supply, and their many stations are constantly increasing. It is planned to spend over $100,000,000 in producing power from the Upper Isère, in Tarentaise, from the Arc, the Drac and the Durance. These streams will be made to give up nearly half a million horsepower. At Serre-Ponçon a reservoir with a capacity of 500,000,000 cu.m. will be constructed.

France has still an immense field for developing hydro-electric power as will be seen by the following table:

	Kilowatt-Hours Obtainable at Low Water	Kilowatt-Hours Obtainble at Average Flow
Alps	1,700,000	3,400,000
Central range Vosges, Jura	660,000	1,320,000
Pyrénées	740,000	1,460,000
Rest of France	300,000	600,000
Total	3,400,000	7,800,000

Power actually obtained at average flow of water:

	Traction and Transmission for Municipal Purposes	Electrochemistry, Electrometallurgic, Miscellaneous	Total
Alps	198,000	306,000	504,000
Central range Vosges, Jura	55,000		55,000
Pyrénées	29,000	22,000	51,000
Remainder	18,000		18,000
Total	300,000	328,000	628,000

New projects call for the development of 500,000 more horsepower.

In Dauphiné several streams contribute the power to run a big variety of industries such as foundries for casting projectiles, iron pipe and the heavy parts used in mounting big artillery. Furnaces, bolt riveters, machine tools, cranes, capstans and shafting are all run by hydro-electric power. One plant turns out per day 110 tons of paper, not counting some miscellaneous war munitions, and consumes some 10,000 hp. in the process. There are more than a hundred other factories in this neighborhood, that of Alevard being the oldest in France and perhaps the oldest water-power operated mill in the world, since it dates from the Fourteenth Century. This large works is now entirely electrified.

But electrochemistry is using much of France's industrial electric energy. The manufacture of nitrates, nitric acid, calcium carbide, chlorates, sulphuric acid and carbolic acid is very intensive because of the needs for powder, explosives and medicaments.

Some figures are as follows: Calcium carbide, 30,000 tons manufactured; nitric substance, 5000; chemical products, 30,000; total, 65,000 tons. Calcium carbide, 42,000 hp. used; nitric substance, 10,000; chlorates, 8000; other products, 10,000; total, 70,000 hp. used.

In 1902 France produced 1400 tons of aluminum, and in 1911 this output jumped to second in the world, France producing 11,300 tons and the United States 14,400 tons.

The immediate future will see another big increase in France's utilized hydro-electric power, for it has been decided to eliminate as far as possible the importation of coal, steel and munitions. By far the greatest progress will be in metal-fusing and reworking furnaces.

After the war the big metallurgic expansion that is expected in France through the supremacy in iron deposits will be aided by the present hydro-electric development. Hydro-electric power will supplement the meager coal supply. In peace time the water power now used to produce electrically synthetic nitric acid will continue to manufacture calcium cyanamid, a cheap nitrogen fertilizer for which an enormous use is predicted. Instead of making picric acid and guncotton, the electrochemical works will produce medicaments and synthetic silks; instead of melinite and cordite, the electric energy will turn out dyestuffs and industrial chemicals for many uses. In developing France's hydro-electric resources, the French leaders are working as much for peace as for war.

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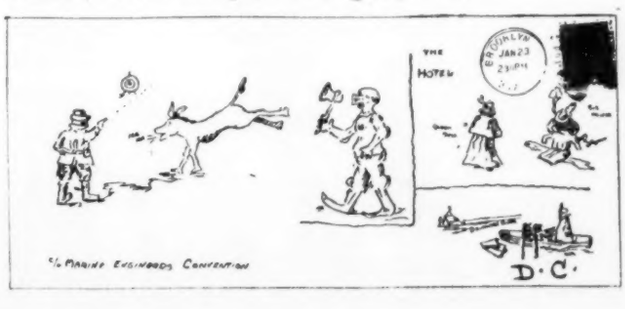
Didn't Bother the Postman

The United States Postal Department frequently handles mail the address of which runs a close second to a Chinese puzzle. The illustration is the reproduction of an envelope that was mailed in Brooklyn and reached the party to whom it was addressed, without any apparent delay. The solution of the address is Mr. Jack Armour, Hotel Raleigh, Washington, D. C.



An Improvised Prony Brake

By R. S. Bayard

We had urgent need of a pulley for a prony brake to test a new design of motor. The two requisites of a prony-brake pulley are that it shall have a hollow rim which will hold the cooling water and that it shall have outside flanges (small ones will do) to hold the brake blocks on the rim.

A rough casting, Fig. 1, for a heavy belt pulley found in the stock yard could be made to serve. The part

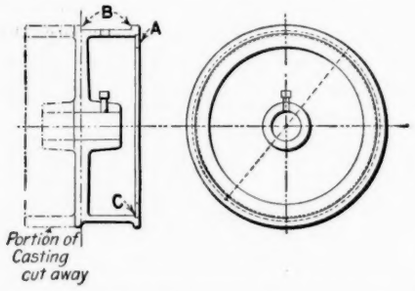


FIG. 1. STOCK PULLEY USED FOR PRONY BRAKE

shown by dotted lines was cut off to allow the pulley to go on, as the shaft room was limited. The face was then turned true, leaving the two flanges B about $\frac{1}{8}$ in. high. Next, the inside flange A, to hold the cooling water, was made from a piston ring "sleeve" casting and fitted into the shallow recess C about $\frac{3}{32}$ in. deep at the inside of the rim. The ring A was made a snug driving fit, which was enough to hold it in place without other fastening.

It is necessary to have a continuous circulation of the cooling water, as it is not satisfactory to run a small

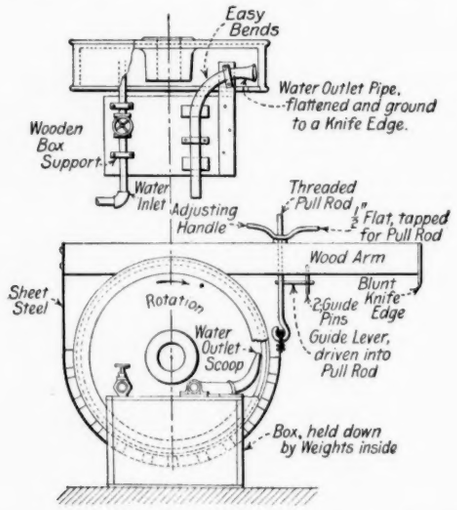


FIG. 2. BRAKE SET UP READY FOR TEST

amount of water into the inside of the pulley and allow the heat of the brake to evaporate it, because it is almost impossible to "float" the brake on the scales if the water is allowed to boil—it has a decided tendency to seize and then let go, causing the brake arm to jump. The water should therefore be supplied continuously to the brake pulley and a curved outlet pipe with a sharp-edged scoop arranged so that it will catch the water at the rim as it spins around with the pulley. Unless the outlet-pipe edges are sharpened at the collecting end and easy bends used instead of elbows, the water will splash; but if nicely shaped and held at the proper angle, the water will be scooped out with scarcely any splash. A convenient set-up of the water piping is shown in Fig. 2. A heavy box set on its side makes a convenient support for the pipes and also for a speed counter if desired.

Another kink, shown in Fig. 2 is worth while, in convenience and steady action. This is the guide that is shown below the wooden arm near the pulley and attached to the pull rod and projecting between two guide pins driven into the wooden arm. The object is to prevent the pull rod from turning when the adjusting handle is turned to alter the tension on the brake band. Unless the pull rod is thus held, it will turn slightly with the adjusting handle, which will have to be turned each time enough to overcome the lost motion before it changes the adjustment. The small lever and the two guide pins, however, keep the pull rod always in position no matter which way the adjusting handle is turned, and the change of adjustment corresponds directly to the movement of the handle. One trial will prove the advantage of this arrangement.

The brake band should be made of a steel band upon which are screwed the wooden friction blocks. If it is

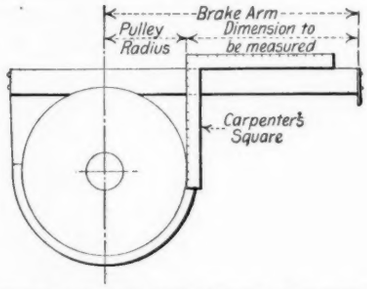


FIG. 3. ASCERTAINING DISTANCE BETWEEN POINTS

made of such material as leather, the stretch, especially when wet, will make it hard to adjust for a nice balance of the beam. With a nonstretchable band every movement of the adjusting handle will have an immediate effect upon the load.

One of the most troublesome details of the calculation of brake-test results is to measure the length of the brake arm exactly. This is sometimes done by means of plumb-lines, but it is difficult to locate the center if the shaft does not project through as far as the edge of the pulley, and the offset from the knife-edge on the end of the arm requires considerable "squaring up" from point to point, with considerable chance for error. If the brake arm is short, a slight mistake in measuring its length produces an appreciable error. In Fig. 3 is shown a convenient and accurate method of measuring the length of the brake arm which, if used in a horizontal position, eliminates a good deal of trouble in the measurement. A level set on top of the arm when adjusting the height of the scales makes this very easy; then to get the length of the brake arm, a carpenter's square is set as shown. The distance from a line scribed on the side of the arm above the face of the pulley to another at the center of the knife-edge plus the radius of the pulley represents the length of the arm which is much more easily and exactly obtained than with a plumb-bob over the center of the shaft. Of course a plumb-bob hung at the pulley face can be used instead of the carpenter's square if preferred.

Editorials

The McGraw-Hill Publishing Co., Inc.

James H. McGraw, one of the early proprietors of *Power*, renews this relationship after a long term of years by the amalgamation of the McGraw Publishing Co. and the Hill Publishing Co., which are to be reorganized as the McGraw-Hill Publishing Co., Inc. The new company will continue the publication of the papers published by each of the constituent companies with the exception that the *Engineering News* and *Engineering Record*, which serve practically the same field, will be consolidated and known as the *Engineering News-Record*. The combination of the means and facilities of these two companies ought to produce an organization full of potency for good to the engineering profession, every branch of which is served by one or the other of its publications.

An Opportunity for Service

That engineers heretofore have been conspicuously absent from participation in public affairs, except perhaps as hired specialists, has long been the subject of much discussion, eliciting numerous suggestions for bringing them more actively before the public. It will be recalled that just two years ago, in an effort to arrive at something tangible, the American Institute of Electrical Engineers devoted a whole evening to the subject. Among the eminent members of the profession taking part in the discussion, there was not entire agreement as to the cause of this condition. Some blamed the engineer's training and were of the opinion that it should be less technical and more liberal. Others believed the very character of this training enabled one to search for facts and thereby formed a qualification for taking up public work. Still others were of the opinion that it is largely a matter of personal qualities and not of training.

Events soon provided an opportunity for recognition, for nothing has been more instrumental in bringing engineers as a class before the public than the splendid cooperation of the national engineering societies with the Government, both directly and through the Naval Advisory Board. The people and Government officials are now beginning to look to engineers as a trained body of men upon whom much depends in the crisis now confronting the nation.

However, aside from the present military aspects, there is a much broader field of work in which engineers can perform inestimable service. This has to do with civic and economic problems. Governmental functions have broadened to an extent undreamed of twenty-five, or even ten, years ago, and as economic pressure becomes more acute the Government appears destined to still further extend its activities. To rightly solve many of these questions will require just the kind of training possessed by engineers.

Obviously more can be accomplished to this end by collective effort, and it is indeed gratifying to note that the American Society of Mechanical Engineers and the American Institute of Electrical Engineers, through their respective presidents, have taken the initiative in the formation of an engineering council which will consist of representatives from all the prominent engineering societies and which will not only deal with questions of mutual concern, but strive to render public service whenever an opportunity is afforded.

Dr. Hollis aptly put it recently in an address before the New York Section of the mechanical engineers, when he said that engineers should get into politics—not in a partisan sense, but for the sake of rendering service.

Measured on an "input-out" basis, there is probably no organization or body less efficient than the Congress of the United States. This may be largely due to our political system rather than to the training of the legislators, yet the time may come when a representation of engineers and fewer lawyers and professional politicians will change this to some extent. Meanwhile there is much to be done. Let the engineer not be blinded by any fancied self-importance, but recognizing his limitations, let him give the best there is in him toward bringing about a condition wherein public affairs will be dealt with according to the facts and in the most efficient manner.

Pulverized-Coal Stockjobbing

One cannot characterize the Pruden process of burning pulverized fuel, as exploited by the Powdered Coal Engineering and Equipment Co. (see page 308) as a fallacy and a fraud with all the cause and confidence that he could so stigmatize a perpetual motion or a holy-water treatment for coal. There is no reason why it will not burn coal that has been pulverized fine enough, as do numerous other appliances that have been devised for the same purpose, but if it burns such fuel a lot better than the best of these, it does not warrant the extravagant claims that are being made for it.

The burning of powdered coal is no new idea. Tons of it are used yearly in cement kilns, metallurgical furnaces, etc. Repeated attempts have been made to use it under boilers, and some of it is so used, mostly in places where it is available through being used for other purposes.

The burning of coal that has been pulverized so fine that it burns like a gas is an impressive process and full of suggestion for the novice. It appears to offer a means of utilizing the cheapest output of the mines with all the cleanliness, convenience, economy and efficiency of a gas furnace, but in practice one soon finds that it is not a gas with which he is dealing; that if the coal has only ten per cent. of ash and all the rest is burned to gas, there will be two hundred pounds of matter to be sprinkled as dust over the neighborhood or plastered

as slag onto the boiler and setting for every ton of coal burned. This and the difficulty of getting a furnace that will stand up when the percentage of excess air is reduced to the minimum, as required for exceptionally high efficiency, together with the cost of drying and pulverizing, have thrown a murky cloud over the dreams of many an inventor and stockholder. The demonstration of the fact that coal can be burned without smoke in a brick-lined inclosure, without any account being taken of the temperature, the excess air, the heat balance, or anything else, does not prove anything that was not known long ago.

Coal may be burned by being coked and gasified in the usual way, especially with a modern mechanical stoker, as fast, as smokelessly, as completely and as economically as it can be by being pulverized and "burned like a gas." There does not seem to be any basic difference between the Pruden device and its predecessors which would enable it to greatly surpass their accomplishments. In fact, neither their accomplishments nor those of the properly designed and operated ordinary furnace leave a margin for any such improvement as that upon which the promoters of the Powdered Coal Engineering and Equipment Co. base their dreams.

Science and Industry

In the early development of most industries the problems encountered are comparatively simple, and in many cases they are solved by cut-and-try methods rather than by logical and scientific reasoning. But as an art advances, it must dispense with the haphazard, unscientific ways of doing things and institute sound, organized scientific methods for predetermining results before an attempt is made to develop a piece of machinery or a manufacturing process. Probably nowhere is this truth more in evidence than in the electrical industry. In the early development, along with the scientific men who turned their attention to a study of this subject were also a large number of workers who had little or no scientific knowledge, but who made many important discoveries. As the industry matured, the field of research gradually narrowed down to the work of the scientist.

A recent example is the incandescent lamp. For years it attracted the attention of many brilliant men, and while some progress resulted, it remained for Dr. Irving Langmuir to make a scientific investigation of what was going on inside the lamp. The results of his study were presented before the A. I. E. E. in October, 1913. Since then the art of illumination has made more progress than during all time previous.

It goes without comment that we have arrived at a state of industrial development where we can no longer fail to recognize all scientific research as the advance guard of industrial progress, and that if progress is to be made, it must come through discovery by the workers in our research laboratories. Dr. Charles P. Steinmetz in one of his recent addresses pointed out that "for ages the chief homes of scientific research have been the universities and other educational institutions. During the last generation, however, the industrial development has been so rapid and the demand for the results of scientific research so great and urgent that the universities have not been able to supply it, and the industries, especially the more powerfully organized modern industries, as electrical engineering, chemistry, etc., had to enter the field of scientific research." The period when it became necessary for industries to establish research laboratories of their own was an important one and may be considered as the bridging of the gulf between science and industry, and it meant the coöperation of business and science for mutual advantage.

One feature of research work that the industries did not take kindly to was investigations that had no prospect of industrial utility. Repeated object lessons have shown, however, that it is rare that some valuable industrial results do not follow sooner or later, no matter how far removed the apparent utility of a scientific investigation may appear. A recent example of this is found in the development of the kenotron for rectifying high-voltage alternating current. The research work that led up to its development did not appear to have any important industrial value, or even the apparatus after it was developed. The investigation carried on under the leadership of Prof. Harris J. Ryan, Stanford University, in conjunction with a number of the Western power companies into the cause of deterioration of suspension-type insulators is an illustration of the possibilties of this device. By the use of the kenotron for obtaining direct current at twenty-five thousand volts and a galvanometer of great sensitiveness, it was possible to increase the measurement of resistances from five thousand to ten million megohms, yet no one thought of this application when the kenotron was developed. This is only another proof of the trite statement that when a new tool is developed almost immediately unsuspected applications of this tool are rapidly found.

If there is one thing that the American business man can be accused of failing to recognize more than any other, it is the need of industrial research. This was one of the first lessons that we learned when the war broke out and we were suddenly cut off from many of our necessities which we had been accustomed to obtain from Europe. This country has unequaled wealth and raw material and men of scientific and industrial ability second to none found elsewhere, but if we are to obtain the technical and commercial position which is justly ours, it will only be brought about by a close coöperation between our scientists and industries.

The McKay Fund

The trustees under the will of the late Gordon McKay, who left a considerable fortune to Harvard University to endow a school of applied science or engineering, object to the transfer of the fund to the Massachusetts Institute of Technology, and have their case before the Supreme Judicial Court on petition of the authorities of Harvard. This fund is now five million five hundred thousand dollars.

Harvard and Technology some time ago agreed upon the terms of the transfer of the fund and the interchange of professors; in fact it is our understanding that Technology had taken over much or all of the engineering curriculum of Harvard. Technology is surely well fitted to use the McKay Fund. The new laboratories are exceptionally well equipped; and it would seem to those disinterested that Technology, because of its present development, could make the fund do all that Mr. McKay desired it should do.

Correspondence

Three Operating Kinks

The following devices may be of interest to readers of *Power*. The first illustrated, Fig. 1, is a portable facing tool. While erecting a second-hand condenser, it became necessary to face up the bosses on the condenser heads. The facing tool was made and consists of a spindle with a cutter inserted and held in place with wedges. A spring and washer, with an adjusting nut, take up the feed as the spindle is turned with a wrench or ratchet. Any desired length of travel may be obtained by lengthening or shortening the spring. Should it be required to face up a boss with an opening much larger than the diameter of the spindle, small pieces of pipe may be used as guides or bushings, these being placed between the cutter and the washer on the far side of the material being faced up. This prevents side play in the tool.

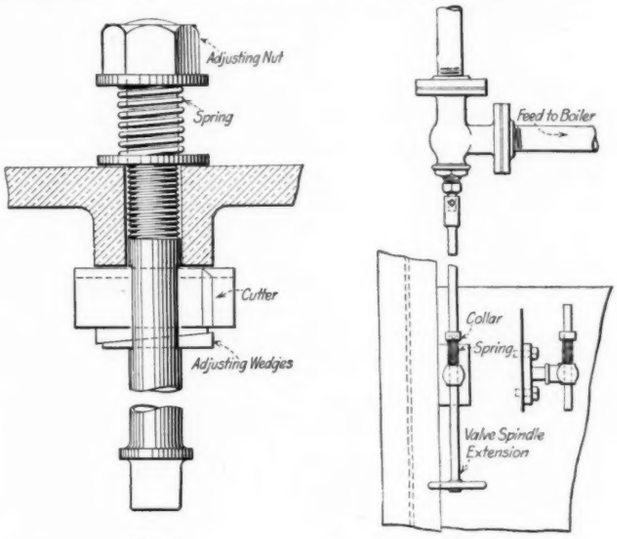


Fig. 1 Fig. 2

FIGS. 1 AND 2. A HANDY TOOL AND A SUPPORT FOR LONG VALVE STEMS

Fig. 1—Tool for facing off bosses. Fig. 2—Extension rod support

Fig. 2 is a device to take up the weight of an extension rod on a boiler-feed valve. With some boilers an extension rod is provided so that the feed-regulating valve can be operated from the firing floor. This rod puts quite a weight on the stem thread and soon wears it out, especially if the firemen are continually opening and closing the valves. This can be remedied by placing a spring and collar above the extension rod guide, as shown in the illustration, and adjusting the tension to carry the weight of the rod. The spring need only to be made of $\frac{1}{8}$-in. or at the most $\frac{3}{16}$-in. material.

Water-level detectors, consisting of diagonal lines on a white surface, show the water level clearly. I have tried both black and red lines and greatly prefer the latter. However, I believe it will be found that a red vertical line about $\frac{1}{8}$ in. thick on a white background is the most satisfactory method of showing the water level in a gage-glass. The water greatly magnifies the red line, and where the broad red line stops and the thin one begins, there the water level is.

I saw a gage-glass some years ago made with a narrow red line in it, but could never get another like it.

Angox, B. C., Canada. J. B. TAIT.

Receiver on Steam Line

On taking charge of the power station here, there was trouble keeping the steam pipe from the boiler to the engine from vibrating and it was hard to keep it tight.

I put a receiver separator three times the volume of the engine cylinder just above the throttle valve, and the vibration was entirely stopped. It was caused by the pulsation at cutoff (400 times a minute, the engine running at 200 r.p.m.). The steam in the receiver acted as a cushion and took up the sudden jar.

Cottage Grove, Ore. J. H. ENGLAND.

Approves Telescopic Oilers

I have just been reading the article, "Steam-Engine Troubles," by Mr. Hamkens in the Jan. 30 issue of *Power*, and note that he does not seem to approve of telescopic oilers.

His statement, "Telescopic crosshead pin oilers, which were in vogue a few years ago, have been a great disappointment," would lead one to believe that telescopic oilers have been abandoned in well-operated plants; but the opposite of this is the case. Nearly all manufacturers of high-grade Corliss engines are now furnishing telescopic crosshead and eccentric oilers as part of the standard equipment on their engines, and about the only place where oil boats and wipers are used is where cost is the prime consideration. We find wipers and oil boats only on the less-expensive types of engines.

At best, drip troughs and wipers can only furnish oil drop by drop, whereas it is generally conceded that if maximum efficiency is to be secured from any unit, stream lubrication is necessary, and there is many an engine which, with drop-by-drop feed, has developed bad knocks at the crosshead and crankpin. When this same engine is equipped with telescopic oilers which feed streams of oil to the pins, the knocks disappear, because a complete oil film is established which fills up the clearance between the bearings and the pins.

Mr. Hamkens admits that the oil is liable to be either thrown out of the boats or forced out by windage. He tries to overcome this difficulty by making the boats deeper; but most of the oil is blown away in dropping from the oil cup to the boat, and of course making the trough or boat deeper will not help catch oil that has blown away by the windage from the flywheel.

Another serious objection to the open oil boat, which every engineer appreciates, is that it collects dirt. No engineer would think of having an open oil cup on a high-grade engine; in fact, all of the oil cups in use

have covers to keep dust from entering, even through the small filling hole. As compared with this the telescopic oiler affords a closed circuit from the oil supply directly to the bearings, and no dust or grit can get into the oil.

Undoubtedly some poor telescopic oilers have been put out which developed trouble in time, but with the modern design of telescopic oiler there is no reason why it should not be just as good after years of service as when new. As for the pumping action, this of course does not occur in properly designed telescopic oilers, for there is enough clearance between the tubes to allow the air to freely work in and out.

I feel sure that it is a backward step to recommend open oil boats in preference to telescopic oilers. Operating engineers are likely in favor of the telescopic oiler.

Milwaukee, Wis. GEORGE F. FENNO.

Distribution of Inertia Effect

I have been much interested in the article on "Compression from a Mechanical Point of View," in the Nov. 14, 1916, issue of *Power*. There are, however, certain points

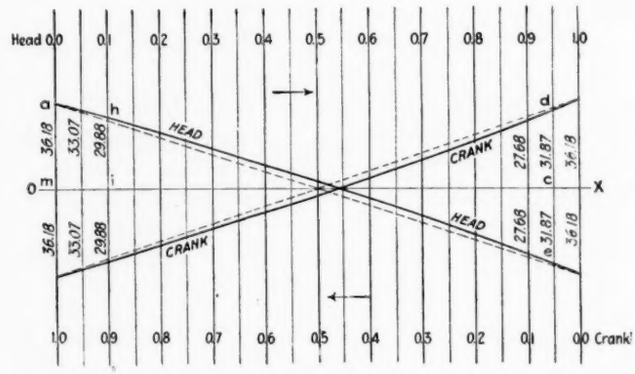


FIG. 1. ERRONEOUS REPRESENTATION OF DISTRIBUTION OF INERTIA EFFECTS

which do not appear to me to be quite correct, and as I have not seen a correction published, I desire to submit one.

In Fig. 1 (Fig. 7 of the article under discussion) the curves representing accelerating forces do not cross the line of zero pressures until after the piston has passed the middle of the stroke. Since the accelerating-force curves might also be used to represent the acceleration by merely changing the scale, it is evident that they should cross the line of zero pressures when the velocity of the piston is a maximum. It is a well-known fact, which can be proved either analytically or graphically, that the velocity of piston is a maximum when the crank and connecting-rod are at right angles.

The accompanying curves, Fig. 2, of accelerating forces have been plotted in a similar manner to those given in the article, but are of somewhat different form. The ordinate *am* represents the accelerating force as the piston starts from the head end of the cylinder. Point *e* is the point at which the crank and rod are at right angles, and ordinate *fc* represents the accelerating force when the piston reaches the crank end of the cylinder. The values

TABLE 1. RATIOS OF PRESSURE EXERTED, BY REASON OF THEIR INERTIA, BY THE RECIPROCATING PARTS IN THE DIRECTION OF THE PISTON'S TRAVEL AT SUCCESSIVE TWENTIETHS OF THE STROKE

Fraction of Stroke Completed	Connecting-Rod = 4 Cranks		Connecting-Rod = 4.5 Cranks		Connecting-Rod = 5 Cranks		Connecting-Rod = 5.5 Cranks		Connecting-Rod = 6 Cranks		Fraction of Stroke Completed
	Head End	Crank End	Head End	Crank End	Head End	Crank End	Head End	Crank End	Head End	Crank End	
0.00	—1.250	—0.750	—1.222	—0.778	—1.200	—0.800	—1.182	—0.818	—1.167	—0.833	0.00
0.05	—1.092	—0.742	—1.070	—0.757	—1.052	—0.769	—1.037	—0.780	—1.025	—0.789	0.05
0.10	—0.945	—0.717	—0.921	—0.723	—0.907	—0.728	—0.896	—0.733	—0.887	—0.737	0.10
0.15	—0.789	—0.679	—0.776	—0.677	—0.767	—0.676	—0.759	—0.676	—0.753	—0.677	0.15
0.20	—0.644	—0.628	—0.636	—0.621	—0.630	—0.615	—0.629	—0.613	—0.622	—0.610	0.20
0.25	—0.504	—0.566	—0.500	—0.555	—0.497	—0.547	—0.496	—0.541	—0.495	—0.536	0.25
0.30	—0.368	—0.493	—0.366	—0.480	—0.369	—0.471	—0.370	—0.463	—0.371	—0.457	0.30
0.35	—0.238	—0.411	—0.242	—0.398	—0.245	—0.387	—0.249	—0.378	—0.252	—0.371	0.35
0.40	—0.114	—0.321	—0.121	—0.307	—0.127	—0.296	—0.132	—0.287	—0.136	—0.279	0.40
0.45	+0.005	—0.220	—0.005	—0.197	—0.012	—0.199	—0.020	—0.190	—0.025	—0.199	0.45
0.50	+0.117	—0.117	+0.106	—0.106	+0.096	—0.096	+0.088	—0.088	+0.081	—0.081	0.50
0.55	+0.220	—0.005	+0.197	+0.005	+0.199	+0.012	+0.190	+0.020	+0.199	+0.025	0.55
0.60	+0.321	+0.114	+0.307	+0.121	+0.296	+0.127	+0.287	+0.132	+0.279	+0.136	0.60
0.65	+0.411	+0.238	+0.398	+0.242	+0.387	+0.245	+0.378	+0.249	+0.371	+0.252	0.65
0.70	+0.493	+0.368	+0.480	+0.366	+0.471	+0.369	+0.463	+0.370	+0.457	+0.371	0.70
0.75	+0.566	+0.504	+0.555	+0.500	+0.547	+0.497	+0.541	+0.496	+0.536	+0.495	0.75
0.80	+0.628	+0.644	+0.621	+0.636	+0.615	+0.630	+0.613	+0.629	+0.610	+0.622	0.80
0.85	+0.679	+0.789	+0.677	+0.776	+0.676	+0.767	+0.676	+0.759	+0.677	+0.753	0.85
0.90	+0.717	+0.945	+0.723	+0.921	+0.728	+0.907	+0.733	+0.896	+0.737	+0.887	0.90
0.95	+0.742	+1.092	+0.757	+1.070	+0.769	+1.052	+0.780	+1.037	+0.789	+1.025	0.95
1.00	+0.750	+1.250	+0.778	+1.222	+0.800	+1.200	+0.818	+1.182	+0.833	+1.167	1.00

of the ordinates from *m* to *e* should be subtracted from the net forward steam pressure, and the ordinates from *e* to *c* should be added, as was done in Fig. 9. Furthermore, area *ame* is equal to area *efc*, but the corresponding areas in Fig. 7 (see Fig. 1) are not equal, indicating a discrepancy, since the algebraic sum of the energy involved must equal zero.

The author has not given the formula which he has used in computing the tables. In plotting the values for the curves in the accompanying figure, the writer has used the formula developed by Professor Klein in his book on the "High Speed Engine."

$$F = (\cos \omega + \frac{R}{L} \cos 2\omega) F_o;$$

F = Accelerating force;

ω = Crank angle;

$\frac{R}{L}$ = Ratio of crank to connecting-rod;

F_o = Centrifugal force which would be produced by the reciprocating parts if they rotated in the crankpin circle.

Instead of dividing the stroke into a number of equal parts, it is more convenient to assume values of ω and

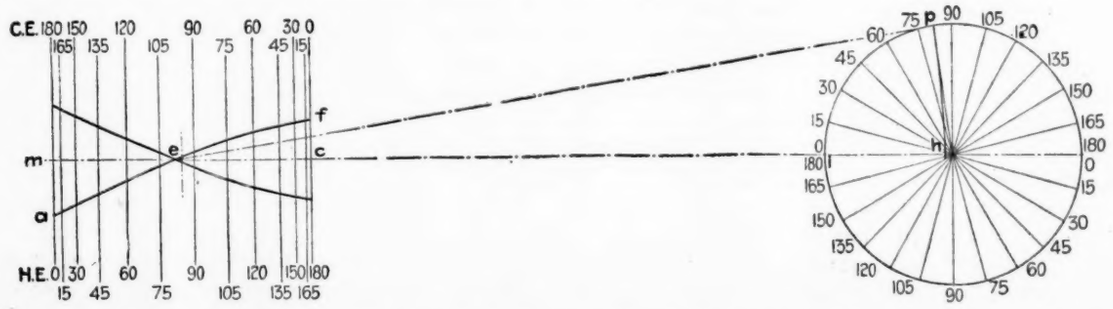


FIG. 2. CORRECT REPRESENTATION OF THE DISTRIBUTION OF THE EFFECTS OF THE INERTIA OF THE RECIPROCATING PARTS

by substituting these in the formula given the ordinates of the curve of accelerating forces can be found. The corresponding position of the piston can be found by laying off a length proportional to the length of the connecting-rod from the center of the crankpin, as *p*, to a point on the center line of the cylinder, as *e;* or by taking a radius proportional to the length of connecting-rod, finding point *e* and scribing an arc *ph*. Then *ih* equals the distance the piston has moved from the beginning of the stroke when the crank is at *p*.

For the constants similar to those given in Table 1, but based on a more nearly correct formula, see Klein's "High Speed Engine," page 39.

WALLACE H. MARTIN,
Instructor in Mechanical Engineering,
Minneapolis, Minn. University of Minnesota.

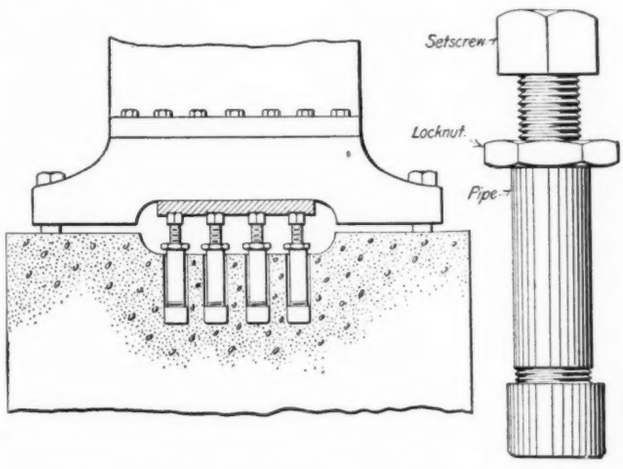
[We stand corrected. The table should be as is shown, computed from the approximate formula

$$F = \frac{Wv^2}{gr}\left(cos\ \omega \pm \frac{cos\ 2\omega}{n}\right)$$

wherein ω is the angle which the crank makes with the line of centers and n the ratio of rod to crank.—Editor.]

A Handy Improvised Jack

One of the many disagreeable jobs met with in factory work is that of lining up heavy machinery, and even where tools and experienced helpers are plentiful, work of this kind is not without its troubles; but in the small



MINIATURE JACKS LIFTING A HEAVY MACHINE

plant, where the largest hoist is likely to be too small, there is good cause for some apprehension on the part of the engineer in charge of such a job.

While working in a general repair shop, I was sent out to get a small plant, that had been shut down for about two years, into shape for starting up. One of the machines geared through a countershaft to the mainshaft had settled so badly that the teeth of the gears were only touching at the corners. We had no heavy jacks or chain-blocks, so with only one young fellow with me the job looked beyond us. However, while going ahead with the rest of the work, I hit upon the following idea.

I had noticed some large hangers in the basement from which I secured the setscrews which are used to keep the box in place. These screws were fitted with locknuts, and the threaded portion of the screw just fitted inside of a 1-in. pipe. This made a neat little jack by holding the head of the screw and turning on the nut.

We drilled holes in the cement under the machine and put a plate, with holes countersunk to receive the heads of the screws, between the machine base and the jacks. When the jacks were in position, it was an easy job to lift the machine to its proper level.

This little jack can be easily made, and as it does not take up much room, it can be carried in the engineer's tool chest.

A. D. PALMER.

Quincy, Mass.

Excess Air in Fuel Combustion

I read with much interest Morgan B. Smith's article, "Excess Air in Fuel Combustion," in *Power* for Nov. 14. The forcible way in which he puts the loss in dollars and cents due to excess of air should attract the attention of power-plant managers and proprietors as well as operating engineers. His graphic illustrations show effectively the rapidly increasing volume of gas with which the chimney becomes burdened and its proportionate capacity for carrying heat to waste.

The deplorable fact noted by Mr. Smith, that it is not uncommon to find plants equipped with many devices installed to check the plant operation attended to in a perfunctory sort of way, if at all, should set thinking those who are responsible for such wasteful condition. Too often the management and not the engineer is to blame.

THE NECESSARY INSTRUMENTS

What are the instruments essential to secure and maintain maximum boiler efficiency? Or, as Mr. Smith puts it, "How may we know how much excess air is used?" Mr. Smith continues: "The first step is to analyze a fair average sample of the fuel it is expected to burn. From this one can calculate the theoretical amount of air necessary per pound of coal, adding thereto about 12 per cent., giving the minimum weight of air required. The next step is to equip the plant with the apparatus which will show continuously the amount of air actually used. For this purpose there are the Orsat type of gas analyzer, the CO_2 recorder, the differential draft gage and, lastly and indirectly, the electric pyrometer." To this statement I fully subscribe when modified as follows: The next step is to equip the plant with an apparatus the function of which is to give indications that will enable the fireman to so adjust the relation between thickness of fire and air supply that complete combustion results with minimum excess of air. For this purpose there is the continuous recording and indicating CO_2 meter, which records the percentage of CO_2 in the engine room for the engineer and at the boiler front for the fireman's guidance; the double differential draft gage, which shows the rate of driving by indicating the resistance of the gases through the boiler and shows the condition of the fire bed by indicating the resistance through the fire; and a pyrometer in the uptake to record the condition of the heating surface. Draft controls combustion intensity, CO_2 controls combustion efficiency, and with proper furnace construction and clean heating surface, CO_2 also indicates the boiler efficiency. Knowing the percentage of CO_2 and temperature of the escaping gases, the engineer can readily calculate the bulk of heat wasted, by the simple formula in which P = percentage of CO_2, T = the tempera-

ture of the escaping gas and t = the temperature of the boiler room.

$$\left(0.24 + \frac{58.46}{P}\right) \times (T - t) = 90 \textit{ per cent.}$$

or more of the chimney heat carried up the chimney per pound of carbon burned, according to the kind of fuel used.

It is obviously impractical, if not impossible, "to equip the plant with an apparatus that will show continuously the amount of air actually used," and it is not to be presumed that Mr. Smith intended this statement to be taken literally; but apparatus is available which will show and record continuously the percentage of CO_2 in the products of combustion, and knowing this and the composition of the fuel, the percentage of excess air can be easily determined by the following formula and a table can be constructed from which it could be read off at once:

$$\textit{Percentage of excess air} = \frac{2{,}100}{P \times (1 + 3Ha)} - \frac{100 + 238Ha}{1 + 3Ha}$$

in which P = percentage CO_2 and Ha = the weight of available hydrogen[1] per pound of carbon contained in the fuel; that is, the weight of hydrogen minus one-eighth the weight of oxygen contained in the coal per pound of carbon. It should be borne in mind also that the amount of excess air necessary to secure complete combustion is not the same under all conditions. Only in very exceptional cases will 12 per cent. excess air prove sufficient.

In the celebrated tests of the large boilers at the Delray plant of the Detroit Edison Co., conducted by Dr. D. S. Jacobus, the excess air varied between 25 and 50 per cent., average 34.55 per cent.; CO_2 between 12.4 and 14.25 per cent., average 13.43 per cent.; and the percentage of CO between 0 and 0.25 per cent., average of six tests considered 0.13 per cent.; practically complete combustion; boiler efficiency 75 to 78 per cent., average 76.44 per cent.

In two tests conducted by Bryant Banister at the Kewanee plant of the National Tube Co. the excess air used was respectively 35.38 per cent. and 38.24 per cent.; the CO_2 was 13.33 per cent. and 13.03 per cent.; the CO, 0.08 per cent. and 0.03 per cent., average 0.055 per cent.; almost perfectly complete combustion; boiler efficiency, 80.38 per cent. and 80.95 per cent. The lowest percentage of excess air used in any authentic boiler tests of which I am aware was that in the tests conducted by F. W. Ballard at the Cleveland Municipal Light Plant, in which the excess air varied in five respective tests between 12.8 per cent. and 23.5 per cent., average of five tests 18.44 per cent.; CO_2 was between 15.05 per cent. and 16.50 per cent., average 15.77 per cent.; CO, between 0.02 per cent. and 0.51 per cent., average 0.174 per cent.; very good combustion, but showing a tendency toward incompleteness. The boiler efficiency varied from 68.58 per cent. to 81.64 per cent. The low efficiency was obtained when driving the boiler 273.83 per cent. above rating, resulting in an abnormal stack temperature of 832.5 deg., which accounts for the comparatively low efficiency obtained from that particular test, the other four averaging 76.58 per cent. despite the fact that in the test giving the lower efficiency nearly 2 per cent. less excess air (namely, 16.9 per cent.), against an average of 18.82 per cent. in the other four tests was used. This was due to the more moderate driving, which averaged 152.24 per cent. above rating instead of 273.83 per cent., giving an average stack temperature of 610.26 deg., or over 200 deg. lower than prevailed during the high-capacity test. It is therefore obvious that in comparing boiler efficiencies in relation to excess air or CO_2, all circumstances must be considered before conclusions can be drawn.

It seems obvious that 12 per cent. excess air would prove to be below the danger line of incomplete combustion in nearly all cases. It is well known to combustion experts that the economy to be gained becomes rapidly less for each per cent. of excess air reduction as the theoretical amount of air required for complete combustion is approached, and that it is not advisable to reduce the excess air too close to the theoretical limit. Mr. Smith continues: "The gas analyzers show the result of existing conditions and do not give a hint of the causes, unless oxygen is determined in addition to the CO_2 in the flue gases."

Oxygen and CO_2 Interdependent

This rather vague statement would seem to indicate that Mr. Smith did not duly consider the purport of what he was saying. Assuming complete combustion of a given fuel CO_2 and oxygen are interdependent, the one cannot be increased without decreasing the other an equal amount. For every molecule of CO_2 formed, one molecule of oxygen (O_2) is consumed, and since according to the physical law of gases (Avogadro's law) all gaseous molecules occupy the same space, it follows that if the one increases the other must decrease in the same ratio.

Air contains 21 per cent. of oxygen, therefore according to Avogadro's law, the products of combustion cannot contain more than 21 per cent. of CO_2, and when carbon is completely burned with an excess of air, the sum of the percentages of CO and the unconsumed oxygen will always be 21 per cent., therefore, $21 - CO_2 = O_2$ and, vice versa, $21 - O_2 = CO_2$; so if we know the percentage of one of these two constituents, we also know the other by simply subtracting its value from 21. Therefore either of these would be a true index of the amount of excess air used. There are good reasons, however, why CO_2 is a more reliable indicator than oxygen. In practice, combustion is rarely complete and pure carbon is not a commercial fuel, and because of this $CO_2 + O_2$ will always be less than 21 per cent.

All commercial fuels contain hydrogen, and since the combustion of this element consumes considerable oxygen, resulting in H_2O (steam), which does not appear in the analysis of the gas, the free oxygen contained in the products of combustion will be less than $21 - CO_2$ by the quantity of oxygen thus consumed, but can be easily determined by the formula,

$$O_2 = 21 - (1 + 2.4\,Ha) \times CO_2$$

and vice versa:

$$CO_2 = \frac{21}{1 + 2.4Ha} - O_2$$

So that in this case also, if the composition of the fuel burned is known and the average percentage of CO_2 or the CO_2 at any given time is determined by analysis, the

[1] It takes 8 lb. of oxygen to burn 1 lb. of hydrogen to H_2O and since the oxygen in the coal exists in the form of H_2O, one-eighth of its weight must be subtracted from the weight of hydrogen the coal contains.

corresponding percentage of oxygen can be quickly found mathematically.

There are, however, two disturbing elements the importance of which must be considered: The first is incomplete combustion resulting in the formation of CO, which consumes oxygen that the CO_2 meter does not detect, but since one molecule of oxygen will form two molecules of CO ($O_2 + 2C$), 1 per cent. of this gas in the products would reduce the oxygen content only one-half of 1 per cent., and since an average of 1 per cent. of CO can result only from ignorance and gross carelessness, which would not be tolerated where a CO_2 meter is installed and intelligently used, the small amounts of CO contained in the gas would not appreciably affect the percentage of oxygen found by calculation. It must not be inferred, however, that check analyses of CO_2, O_2 and CO can be entirely dispensed with, where automatic CO_2 meters are installed. They are necessary for the purpose of diagnosing as well as checking the correctness of the records obtained.

Air Required To Burn Sulphur Negligible

The combustion of 1 lb. of sulphur requires 1 lb. of oxygen, whereas it takes 2⅔ lb. to burn 1 lb. of carbon, from which it readily appears that the amount of oxygen used to burn the generally small amounts of sulphur contained in the fuel compared with that required to burn the carbon is insignificant and its effect on the oxygen content in the gas is practically nil. The theoretical interdependence of the percentages of CO_2 and O_2 is therefore not appreciably disturbed by interfering elements. This being so, determining the oxygen by analysis can give no more clue to the cause of unsatisfactory operation than the percentage of CO_2. Both are true indexes of the amount of air supplied per pound of coal used. The CO_2 meter indicates and records whether there is an excess and how great an excess in the air supply. A knowledge of the percentage of oxygen can only corroborate this information. Nor can it give any clue as to the cause of an excess or deficiency of air, any more than the steam gage can give a clue as to the cause of high or low steam pressure. It is up to the operators to find and rectify the cause, but it must first become known that there is something wrong before a remedy can be intelligently applied, and the effect of the remedy applied must be immediately indicated if the cure is to be prompt and effective. To give this information at the time and place required is the function of the CO_2 meter.

Mr. Smith further says: "It is well known that high CO_2 can be attained at very low boiler outputs, a fact which firemen are not slow to learn, especially when bonuses are paid for high content of CO_2 in the flue gases." A sly, lazy fireman would not succeed in reaping unearned benefits as his mates would soon bring him to time. The resistance to the gases through the boiler is a good index of the rate of driving and when a differential draft gage is conspicuously placed on every boiler, the shirker is quickly detected. Steam-flow indicators on all the boilers immediately reveal the shirker.

Mr. Smith prefers the electric pyrometer to assist in the control of boiler efficiency. He says: "Pyrometers installed over the fires or on the top of the first pass in water-tube boilers afford a measure of the output of the boiler which must be taken into account."

He evidently intended that there should be a pyrometer in the uptake also, for he says further on: "With pyrometers installed as stated, it is possible to maintain a uniform temperature drop through the boiler." His graphic illustration shows what he means. But the temperature drop shown is anything but uniform. Just such a diagram would result if the driving were increased from an extremely slow to a high rate, irrespective of the excess air used within wide limits. The percentage of excess air might even be much less with the low than with the higher rate of driving and the resulting temperature differences between furnace and damper be very similar to those shown by the diagram.

The temperature drop between furnace and uptake is an index, but not "a measure of heat absorbed by the boiler." Since the furnace temperature varies with the rate of driving as well as the excess air used, it cannot be a reliable index—much less a measure of the latter. There is no electric pyrometer in existence that will stand up under the heat of a boiler furnace if placed above the first pass, as Mr. Smith suggests. The temperature in the uptake depends upon three factors; namely, condition of the heating surface, rate of driving and the excess air. A pyrometer in the uptake can give no information as to which factor predominates.

Passaic, N. J. E. A. Uehling.

Piping Separator and Heater

The method of piping an oil separator and open feedwater heater in connection with an exhaust-steam heating system described by Carl P. Mann in the issue of Nov. 28, 1916, I consider defective and unnecessarily expensive, as it will be seen that by closing valve *B* and the bypass the engine can be stalled, also that if the valve in the bypass is not tightly closed, steam may be wasted through the exhaust head unnoticed, so that the arrangement is not entirely foolproof. It is even dangerous if the heater receives the discharge from live steam traps, as there is a possibility of pressure building up in the heater enough to cause an explosion when the heater outlet valve is closed.

The arrangement involves an independent separator and a trap to drain it, four gate valves, three large tees, an elbow and two extra pieces of piping, and the only advantage claimed for it is the ability to cut the separator out of circuit for cleaning, which is not necessary if the separator is of the self-cleaning type. This may be the best way to use equipment of the type shown, but a heater and receiver with self-contained cutout valves is, I believe, superior in every respect.

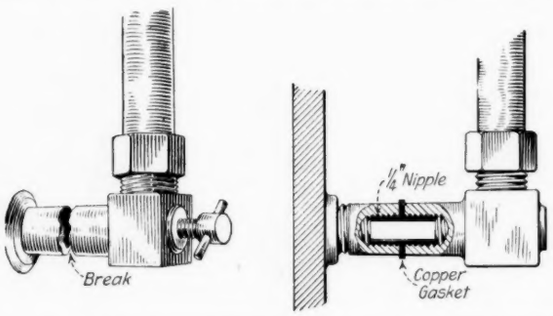
Philadelphia, Penn. William B. Campbell.

Insoluble Impurities in Oil can easily be detected (although the nature of them cannot be determined) by mixing a quantity of oil with gasoline so that it will filter through blotting paper. Any such impurities are deposited on the paper, and can be seen.

Fires Caused by New Form of Carelessness—It is estimated by the Actuarial Bureau of the National Board of Fire Underwriters that small electrical household devices are causing fires at the rate of 30,000 or more per year in the United States. It is safe to say that most of these fires are entirely preventable and can be charged to nothing but carelessness on the part of the user. Various "safety" devices have been added by certain of the manufacturers of these articles, and among them are some that are fairly effective, but there is one absolute precaution which should be borne in mind at all times by every user; namely, that of shutting off the current when not personally and continuously supervising the use.

Repairing a Broken Lubricator

The gage-glass connection on a small lubricator was accidentally broken. There was no other like it about the plant, and it would take four or five days to get one from the factory. In the meantime the pump would have to be oiled somewhat irregularly by means of an improvised rig. The illustration shows how the bracket was neatly repaired with the ordinary tools found in a plant.



GAGE-GLASS CONNECTION BROKEN AND REPAIRED

There was enough stock to permit a full ¼-in. pipe thread to be cut on the inside of the connection. A piece of ¼-in. pipe was threaded for about ¾ in. and cut off. The fractured ends were filed off smooth and a joint secured by means of a copper gasket and assembled as shown. The lubricator has worked without a leak, and it was not considered necessary to change to the new part when it was received from the factory. F. W. Bentley, Jr.

Missouri Valley, Iowa.

Operating Under Difficulties

One of the mottoes of every power plant should be, "Keep the engine running," if possible with safety, as even a short shutdown at the wrong time is often costly. A case in point occurred not long ago in a plant in New Mexico. The equipment was a 250-hp. twin-horizontal four-stroke-cycle crude-oil engine, furnishing power for a mill that crushes ore and separates the metal and also drives a compressor that furnishes power for the mines.

Owing to a delay in the arrival of a tank car of crude oil, we were forced to resort to distillate with a specific gravity of 43 deg. Baumé for fuel and ran on this oil for six days. The following points were noted in the operation of the engine: Contrary to what might have been expected, a higher spray pressure was necessary to prevent smoking in the exhaust than was customary when running on crude oil. The fuel consumption was about 20 per cent. more with the distillate. The spray valves had a tendency to become filled with carbon quicker with the distillate than with the crude oil, and the temperatures of the cylinders were slightly higher. The timing of the engine was unchanged from that used while burning crude oil; that is, firing about 7½ deg. before the center with an engine speed of 200 r.p.m.

Shortly after this experience a heat crack developed in the cylinder liner due to insufficient cooling. The water had not been softened and contained a large amount of scale-producing matter, which rendered efficient cooling difficult. Because of this the temperature of the water leaving the cylinders has been kept at about 110 deg. F. A water-softening plant is now being installed and should obviate this evil.

A new liner was ordered to be sent by express. The crack kept enlarging, however, allowing more and more water to enter the cylinder, until finally it was decided to cut the cylinder out. The engine was shut down, and all the water, high-pressure air and oil connections were blocked off, and the intake valve removed from the cylinder with the cracked liner. The engine was then started up on the good cylinder (left-hand) and we ran thus for five days until the new liner arrived.

Of course we had to operate under reduced load, but under these conditions none of the bearings showed signs of overheating. The regulation was not as good as when operating with both cylinders, and the fuel rate was slightly higher than usual. Theodore M. Robie.

Hanover, N. M.

Re-using Manhole Gaskets

It seems to me that Mr. Dale's article on the proper care of manhole gaskets in the issue of Jan. 30, page 138, may be rather misleading to some and instead of tending to economy may lead in the other direction. I have seen this plan tried out in several plants in exactly the way Mr. Dale describes, and although it works successfully in some cases, one or two failures are enough to make it anything but economical.

Of course, if a careful engineer in a small plant does the work himself, he can get satisfactory results, but where such work as heading up is done by more or less indifferent help, as is often the case in larger plants and where even with the best of labor the work has to be rushed to get a boiler back into service, it will not always be successful. With large water-tube type boilers with three or more drums, the failure of one gasket means that the boiler must come off the line and be cooled down before the gasket can be replaced. This means a loss of from two to four tons of coal, which at present prices would equal the cost of quite a supply of gaskets, to say nothing of the extra labor and loss of the service of the boiler, which at times may be very serious—in fact, more so than the monetary loss.

Taking everything into consideration from the central-station point of view—safety plus service—the most economical way is a new gasket each time and in addition, all the care that Mr. Dale advises, for his way of putting on a new gasket is correct.

As to the woven asbestos gasket, there is a diversity of opinion. I know of one large central station carrying 225-lb. pressure which uses gaskets cut from sheet packing for both manholes and handholes with the best of results.

There are also on the market molded asbestos gaskets that I have used with success on boilers carrying 155-lb. pressure. E. Palmer.

Philadelphia. Penn.

The Cost of Increasing Efficiency—Assuming the cost of power at 1c. per kw.-hr., an increase in efficiency from 86 per cent. to 87 per cent. on a 15-hp. 850-r.p.m. motor operating at 75 per cent. load, 8 hr. per day, 300 days per year, results in a decrease of 300 kw.-hr., or a saving of approximately 1.3 per cent. of the basic cost of the motor. The increased cost of the motor to obtain this 1 per cent. improvement in efficiency is 3.3 per cent. of the basic cost.

Inquiries of General Interest

Part of Boiler Subjected to Greatest Pressure—In what part of a boiler is the pressure greatest? A. T.

The lowest interior surface of a boiler is subjected to the greatest pressure as it must sustain the pressure due to the weight of the water in addition to the superimposed pressure of the steam.

Rating of Electrical Apparatus—Which is the proper method of rating electrical apparatus; by input or by output? E. M. A.

All electrical apparatus such as generators and transformers should be rated by electrical output; motors should be rated by mechanical output.

Pitch for Given Size and Per Cent. of Rivet Holes—What would be the pitch of the rivets of a boiler joint with rivet holes ¾ in. diameter to retain 70 per cent. of the stock of the plates between the rivet holes? W. L. C.

As the diameter of the rivet hole would be 30 per cent. of the pitch, the pitch would be $(0.75 \times 100) \div 30 = 2\frac{1}{2}$ in.

Heated Commutators—When operating under normal load, what would cause the commutator of a direct-current machine to run hot? M. A. W.

Excessive heating of commutators may result from several sources: Among others, too much tension on the brushes, poor quality of brushes, defective insulation between the bars and lack of lubrication in the brushes.

To Protect Smoke Flues from Corrosion—How can smoke flues be prevented from rusting out rapidly? G. E. D.

Interior corrosion of iron or steel-plate flues is usually more rapid from use of steam blowers or moisture in the fuel and fuel containing sulphur. One of the best protective coatings is a wash of portland cement and water mixed to a consistency of thick paint and applied with a stiff brush.

Fire Side of Tubes To Be Taken As Heating Surface—Should the interior or exterior surface of boiler tubes be estimated as the heating surface? L. T.

The surface that actually receives the heat should be the measure of the heating surface. On this account the outside diameter of water tubes and the inside diameter of fire tubes are to be taken in estimating the number of square feet of heating surface.

Erosion of Valves Increased by Wiredrawing—Why is wiredrawing steam through partly opened valves more destructive of their disks and seats than when the valves are fully open? M. R. A.

The more restricted the opening the greater the drop of pressure for a given rate of discharge through the valve, and the erosive action of the steam is increased by its higher velocity of flow through the aperture.

Operating One Side of Duplex Pump—If one of the water pistons of a duplex pump became loose from the piston rod, how could the pump be operated? E. B.

The pump could be continued in complete operation of one side by removing the loose water piston from the pump and leaving all other parts intact. Jumping could be reduced by opening the steam-cylinder waste cocks, by tightening the stuffing-box glands or by partly stopping off the steam ports of the disabled side of the pump.

Adjusting Slide Valve to Equalize Exhaust—What would cause a slide-valve engine to have much heavier "drag" exhausting from one end of the cylinder than from the other, and how could the trouble be remedied? J. A. H.

There would be unequal steam admission, and also unequal exhaust from opposite ends of the cylinder, if the valve travels farther to one side of the ports than the other. The travel can be equalized and the relative steam admission and exhaust can be adjusted by lengthening or shortening the valve stem.

Piston Clearance and Clearance Volume—What is the difference between "piston clearance" and "clearance volume" and how are they expressed? G. J. R.

The piston clearance is the distance the piston would have to be moved beyond the end of its stroke to strike the head of the cylinder and usually is expressed in inches or fractions of an inch. Clearance volume is the volume of the end of the cylinder, waste space, and steam passages from the valve seat to the piston when the piston is at the end of the stroke. The clearance volume of each end of the cylinder is usually expressed as a percentage of the volume displaced by one stroke of the piston.

Effect of Increasing the Frequency—What effect would increasing the frequency of an alternating-current circuit have upon the apparatus connected to the system? E. H. B.

The effect would depend upon the kind of load that is connected to the circuit. If the load consists of incandescent lamps, the effect will not be noticeable unless the original frequency is so low that the lamps flicker, and in that case increase in frequency would stabilize the light. When arc lamps are used, the current will be decreased and there will be less light given out by the lamps, caused by the inductance connected in series with the arc.

The speed of induction of synchronous motors will be increased directly as the frequency, since the speed of this type of machine is a function of the number of poles and frequency.

Unequal Cutoff Due to Angularity of Connecting-Rod—When a D slide valve has lap and with the same amount at both ends, why does cutoff occur later in the forward stroke and compression occur later in the return stroke of the piston? F. G.

On account of the angular movement of the connecting-rod the first half of the forward stroke and the latter half of the return stroke are each accompanied by less than one-quarter of a revolution of the shaft, and the piston must travel farther for a given angle of rotation of the crank and eccentric when the piston is in the crank-end half of the cylinder. As the motion of the valve depends on the angular rotation of the eccentric, it follows that the valve events that occur during the forward stroke are later and those occurring during the return stroke are earlier in the stroke. Hence when a slide valve has the same lap on each end when in the middle of its travel, the point of cutoff is later in the forward stroke and the exhaust closes earlier, resulting in higher compression in the return stroke of the piston.

Strength and Stress of Girth Seams—How is it determined that the girth seams of a cylindrical boiler shell are twice as strong as the longitudinal seams? F. C.

A longitudinal seam has practically the same strength per inch or other unit of length as a girth seam of the same type and construction. But the stress per unit of length of a girth seam is only one-half as much as for a unit of length of a longitudinal seam. If p = the internal pressure per square inch and d = the diameter of a boiler in inches, then the stress in pounds per inch of length of a longitudinal seam would be $(p \times d \times 1) \div 2$, or pressure per sq.in. $\times$ 1 $\times$ d $\div$ 2. The stress per inch of length of a girth seam would be the total stress resisted by a circumferential seam divided by its length in inches. Neglecting any reduction of area of the boiler head by presence of tubes, and any relief of stress rendered by the staying action of the tubes and braces, the total stress resisted by a complete circumferential seam would be equal to the gross area in square inches of one head of the boiler, in square inches, multiplied by the pressure per square inch, or $p \times \pi r^2 = p \times 3.1416 \times (\frac{1}{2}d \times \frac{1}{2}d) = p \times 3.1416 \times \frac{1}{4}d^2$.

As the length of a circumferential seam in inches would be 3.1416 $\times$ d, the stress per inch length of the girth seam would be $\frac{p \times 3.1416 \times \frac{1}{4}d^2}{3.1416 \times d} = p \times d \div 4$, or only one-half as much as the stress per inch of length of a longitudinal seam.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Protecting Transformer Neutrals*

By H. M. Collbohm

It is a well-established practice to protect the low-tension windings of transformers through a spark gap, against the excessive potentials induced in them through capacity effects between the high-tension and low-tension windings under abnormal voltage conditions on the high-voltage side. There exists, however, a distinct danger to the high-voltage side which is not generally recognized and which cannot be guarded against by the ordinary types of arresters of American manufacture, such as the electrolytic and multigap types, installed in the usual way. This danger is evident from the following consideration:

LIGHTNING DISCHARGE ON TRANSMISSION LINE

If during a lightning storm a discharge takes place from a cloud above a transmission line, the electrostatic charge, previously induced by this cloud in equal quantities and like polarity on all three wires of a three-phase line, is suddenly set free and travels in both directions along the line. Inasmuch as for all practical purposes the three wires of the same line offer the same impedance, and as this is also true of the main power transformers on either end of the line, the speed of propagation of the released charge or, more correctly, that portion of it which has not been discharged over the insulators or through corona, is exactly alike in all three wires. Consequently the neutral point of the transformer, if connected in Y, constitutes the reflection point for all these traveling waves. If the potential of this traveling wave after having reached the station is below the value for which the arresters have been set, it will pass through the transformers; and as the charges from all three wires meet at the neutral point, they build up to three times their individual potential at that place. Although the potential difference to ground of each individual charge may be below the safe electrostatic stress of the transformer winding and terminal bushing, the combined effect of the triple voltage is likely to produce disastrous results.

The writer was confronted with this condition in the operation of the Peninsular Power Co.'s system at Iron Mountain, Mich., where the 66,000-volt step-down transformers in the Iron River substation showed repeatedly momentary arcing from the neutral terminal of the transformers to the case, a distance of three feet. In one instance the arc formed between the neutral lead under oil and the transformer iron, resulting in the burning off of the lead.

In order to provide a discharge path for this dangerous potential, a multigap arrester will be installed at the neutral point and adjusted to discharge at 42,000 volts. This high-voltage setting of the arrester became necessary for the reason that the system operates with the transformer neutral at the generating station grounded through a metallic resistance to avoid service interruption in case of accidental grounds on one of the line wires and which under such conditions, otherwise harmless, would produce a potential difference of 38,000 volts between transformer neutral and ground. A multigap arrester was chosen in place of an electrolytic arrester in order to avoid the inconvenience of providing for the necessary special arrangement and constant attendance for the regular charging of the latter.

SPHERE GAP AS A MEANS OF PROTECTION

On account of the urgent need for protection of the substation transformer neutral and the present inability of the manufacturers to effect short-time deliveries, a makeshift arrangement has been used to serve until the multigap arrester is received. This arrangement consists of two zinc balls 5 in. in diameter, set 6 in. apart, each supported by an iron rod and connected to the neutral point and ground respectively, thus forming a relief gap for the transient excess potential. The sphere spark gap was chosen on account of its greater sensitiveness under sudden impulses as compared with the needle gap. The spheres have been made of zinc on account of the arc-extinguishing tendency of this metal.

This arrangement has worked very well during recent lightning storms, when discharges over this spark gap have repeatedly been observed. This proves that protection against the aforementioned transient disturbances can be obtained by a shunted spark gap. It is of interest to note that the spheres were originally set 12 in. apart by error, and even with this wide setting the previously mentioned discharges have been observed, indicating the surprisingly high potential of about 350,000 volts between neutral and ground.

It should be noted that the trouble occurred only on the transformer neutral in the substation, while no disturbances of this nature were observed in the generating station where the metallic ground rheostat between transformer neutral and ground served to drain off these transient charges.

The danger from this source is present only in Y-connected transformers where the neutral acts as a reflection point. If delta connection is used on the high-tension side, the incoming charge divides at each corner of the delta, one half going into one transformer and the other half going into the other transformer. The middle point of each transformer will in this case be the reflection point, but the accumulation of potential at this place will therefore not be greater than that of the original charge on each line wire at the transformer terminal. This statement, however, must not be taken to dispute the fact that potentials higher than that possessed by the original charge at the transformer may exist within the transformer winding, due to the piling up of potential through reactance under high frequency or steep wave fronts. However, as experience proves that the electrostatic charges actually pass through the transformer and build up at the neutral point to destructive potentials, it appears that their wave front has become less steep, due to the impedance of the transmission line between the point of lightning discharge and the transformer station. From this consideration it would seem that long lines should be more subject to this danger of potential rise at the neutral than those of shorter lengths where the impedance may not be great enough to flatten out the transient wave front sufficiently to permit of its passing through the windings. In this latter case, however, danger is present from abnormal potential rises within the transformer due to a reactance, as mentioned before.

From the foregoing it is evident that protection must be provided for the neutral point of transformer banks, especially on long lines. Additional protection can be obtained through the installation of condenser arresters, manufactured at present in Europe only, on the line side of the transformer leads, as they tend to absorb all transient charges having steep wave fronts or high frequency and thereby prevent, or at least reduce, the danger from abnormal voltage rises within the windings.

*From a paper presented at the fifth midwinter convention of the A. I. E. E., New York, Feb. 14, 1917.

Vulcanizer Explodes

About 9:30 a.m. Saturday, Feb. 10, a 60-in. by 18-ft. vulcanizer exploded at the plant of the Luzerne Rubber Co., Trenton, N. J. The vulcanizer was blown wide open and an idle one, a few feet away, was badly damaged. One side of the one-story structure was blown out, and the roof fell in. Windows were shattered in another factory building across an alley, and one man was slightly injured there. None of the rubber company's employees was injured, although five or six men were working in the room where the explosion occurred.

The vulcanizer was supposed to carry 50 lb. steam pressure and was used for curing rubber goods. The shell was originally $\frac{7}{16}$ in. thick with double-riveted lap-joint longitudinal seams, single-riveted girth seams and of standard strength and pattern. The rupture occurred in the sheet near the first girth seam where the sheet was but $\frac{1}{8}$ in. thick. Pitting and corrosion showed very plainly all over the inside of the shell. A pressure-reducing valve was in service in the steam line, but there was no safety valve on the vulcanizer. The steam gage was found after the explosion, stuck at 40 lb. The vulcanizer was not insured and evidently was not subjected to inspection.

Electrical Goods in Cuba

The Bureau of Foreign and Domestic Commerce, Washington, D. C., has just issued a Special Agents Series, 40-page bulletin, No. 128, on "Electrical Goods in Cuba," by Philip S. Smith. Copies of this bulletin may be procured from the Superintendent of Documents, Government Printing Office, Washington, D. C., at 5c. per copy. This bulletin gives a brief description of the country, a list of some 70 central stations, the character of their equipment, motive power used, construction of power houses, lighting, heating devices, miscellaneous applications of electricity, power for sugar mills, possible future field for electricity, customs classification of electric goods, statistics of imports, packing, trade-mark registration, advertising, and where to secure lists of dealers and users. A brief abstract of this bulletin is given here.

Although the climate of Cuba is damp, the amount of moisture present is not sufficient to be destructive of good electrical insulation. However, some difficulty is experienced

with the grounding of small devices, especially on 220-volt circuits, owing to the absorption of moisture by the insulation.

The United States received about 81 per cent. of Cuba's total exports and furnished 67 per cent. of the imports for the calendar year 1915. The imports of American electrical goods so far as can be learned is above this percentage, varying from 77 to 88 per cent. of the total electrical imports for the fiscal years ended June 30, 1912 to 1915.

There are in Cuba approximately 120 electric-lighting plants. These vary in size from stations in small towns requiring only 20 kw. or less to the station of the Habana Electric Railway, Light and Power Co., the main generating equipment of which consists of three turbo-generators, each having a normal rating of 12,500 kw.

EQUIPMENT OF AVERAGE CENTRAL STATION

The equipment of the average typical central station in Cuba consists of one or more oil engines, usually of the Diesel type, belt-connected to a direct- or an alternating-current generator. The capacity of the generator in the majority of plants is 100 kw. or less. Practically all the high-tension lines on the island are used to transmit very small amounts of power from one town that has an electric plant to another that is not large enough to require a plant of its own. For such purposes the voltage employed varies according to local conditions, but probably the highest voltage so used is that between Santa Clara and another town about 10 miles distant. The voltage of this transmission line is 11,000, but is used only between the step-up and step-down transformers, which are located at the town limits in each case. Within the town the voltage is 3150, at which the current is generated.

Alcohol is practically unknown as a fuel in Cuba. Owing to the low cost of producing alcohol, it should prove a solution to the problem of the increasing cost of fuel, for it can be manufactured in very large quantities and delivered at the door of every plant with a minimum amount of freight and handling charges. Gasoline-engine-driven sets are rarely seen, owing largely to the high cost of gasoline. At the time of writing this report (August, 1916) it sold for 42 to 50c. per gal. according to the location of the purchaser. There are one or two producer-gas engine-driven sets in operation, but the number is not increasing.

Steam plants are the most numerous aside from those using oil engines. For fuel the large plants burn coal, the cost of which is approximately $8 per ton at the plant. Many of the smaller plants burn wood which is cut locally. There are no large hydro-electric developments in Cuba as there are no large rivers, but many small streams have been utilized as sources of power for the generation of electricity, and there are other streams that can be developed if there is any need for the power where they are located. The largest hydro-electric plant in Cuba is now being constructed near Guantanamo. It will have a capacity of nearly 1500 hp., which will probably be available the year round.

DAY LOAD ON CENTRAL STATIONS

Outside of the electric power that is generated at the different sugar mills for their own consumption, practically the entire output of the power plants in Cuba is used exclusively for lighting purposes. The island is not a manufacturing country in the usually accepted sense of the word; while sugar is a manufactured product, there is no other large industry requiring power on the island. For this reason there are only six central stations that have a day load; all the rest give service for only 6 to 12 hours at night. The very small plants are run for 6 hours unless they have a contract with the town for street lighting, when they are usually operated 12 hours per day.

Excepting in the large cities nearly all the current is sold on a flat-rate basis. The cost for a 25-watt lamp per month is approximately $1.25, although it varies with different stations. In a few of the cities meters are being introduced, but this is an expense that most stations do not want to incur unless they have a 24-hour load.

In Cuba electric-lighting fixtures cannot be too fancy or ornate, or loaded down with too many ropes of crystals, or have too many diamonds or pencil-shaped pendants surrounding them to suit the taste of the natives. Most of these fixtures have been furnished by Germany, Bohemia and Austria, but now many are being imported from Spain.

The largest traction system in Cuba is in Havana, which operates about 400 motor cars, all of which are American made. The car bodies are now being built in the shops of the railway company where they use native woods that stand the climatic conditions better than the Northern woods. The running gear, motors, wiring and controllers are all standard American equipment.

At present there is probably not a single electric vehicle in Cuba. The Habana Electric Railway, Light and Power Co. is expecting to carry on some experiments with storage-battery stages to take the place of the mule-drawn stages it now operates.

While every sugar mill has had its electric plant for lighting purposes for a long time, it is only within the last five years that engineering studies of conditions have proved that electric power is far superior to the steam drive formerly used. Practically all the power generated in electrified sugar mills is three-phase 60-cycle 440-volt alternating current. A majority of the motors used are of the squirrel-cage type. In one of the first mills to be completely motor driven is installed 131 motors having a total horsepower of 3012. The capacity of this mill is rated at 200,000 bags of sugar per year.

The generating equipment selected for sugar-mill work is the turbo-generator, arranged to operate from the same boilers that were used for the previously installed steam engines. Therefore they must work on a boiler pressure of about 100 lb. and with a back pressure of 6 to 8 lb. The cooking processes use a large quantity of low-pressure steam, and in some instances a portion of this is furnished direct from the low-pressure element of the turbine.

NEW PUBLICATIONS

THE MECHANICAL WORLD POCKET DIARY AND YEAR-BOOK FOR 1917. Published by Emmott & Co., Manchester, England, and for the United States by the Norman, Remington Co., Baltimore, Md. Thirteenth edition. Revised. Cloth; 330 pages; 4x6 in.; illustrated. Price, 35c.; by mail, 40 cents.

Several new features have been introduced in this edition. The steam-engine section has been largely rewritten, and new tables have been introduced giving dimensions of piston rings, governors, etc., also notes on lubrication and on antifriction bearings. A new section has been introduced dealing with the heat-treatment of steel, including notes on annealing, hardening, tempering, etc. There are tables giving the dimensions of flanged couplings and for the calculation of springs. Many new features have been introduced relating to electrical engineering and power transmission.

PIPES AND THE PUBLIC WELFARE. By R. C. McWane. Published by the Sterling Press, New York. Cloth; 165 pages; 5x7½ in.; illustrated. Price, $1.

This volume contains but four chapters, one of which deals with the pipe question for water conduits from the historical standpoint, going as far back as the early Babylonian period. Another chapter deals with the materials and methods of making metal pipe. Both of these chapters make interesting reading. A third chapter takes up some technical and historical data on metal-pipe deterioration. It consists largely of extracts from various papers and reports presented at one time or another by several authors. This is the most valuable chapter, containing, as it does, data regarding the deterioration of metal pipes and especially as to the superiority of cast-iron over steel pipes. The concluding chapter deals with wood pipe of the built stave type of modern design such as used to a large extent for reclamation purposes where great volumes of water are carried over long distances.

STRENGTH OF SHIPS. By Athole J. Murray. Published by Longmans, Green & Co., London; Fourth Ave. and 30th St., New York. Cloth; 400 pages; 5½x8½ in.; illustrated. Price, $5.

As the name implies, this volume deals wholly with the strength of the materials composing the hull structure and the manner of making riveted joints, etc. There is nothing that will interest the steam engineer as pertaining to his work except the sections dealing with shafts subjected to pure torsion and the combined bending and torsion of shafts. The volume is more in keeping with the requirements of the designer who is interested in shipbuilding, and as shipbuilders cannot afford to ignore the problem of strength of materials in its application to ship design, the book seems to contain much that is of value regarding the subject. The author has gathered data from various sources and has brought together some of the more recently published researches of shipbuilders. He has realized that while the results of some theories are used constantly, the use of others is less frequent, and his practical experience has enabled him to devote the proper space to each part of the subject. The book is divided into fourteen parts, A to N, each part subdivided into several sections. The general heads treated are Stress, Strains and Elasticity, Materials of Ship Construction, Beams, Columns, Shafts, Longitudinal Strengths, Transverse Strengths, Water-Tight Bulkheads, The Strength of Plating, Fastenings, Rigging and Outboard Fittings, Plate Brackets and Rudders. The work is full of formulas, and numerous examples are given. The chapter on materials employed in ship construction deals briefly with the principal materials used, together

with the uses to which they are put. The English system of units has been adopted throughout. Gravitation units are, where possible, stated in pounds and tons of 2240 lb.

RIVETED BOILER JOINTS. A treatise on the design and failures of riveted boiler joints, with numerous original diagrams enabling the designer to design any desired joint without calculation. By S. F. Jeter, B.S., M.E. McGraw-Hill Book Co., Inc., New York. Cloth; 8x11 in.; 155 pp. Price, $3.

If we see its purposes and possibilities aright, here is a book that will become as standard upon the drawing board of the designer of boilers as are the traverse tables upon the desk of the surveyor. The author is chief engineer of the Hartford Steam Boiler Inspection and Insurance Co., a member of the Boiler Code Committee of the American Society of Mechanical Engineers, and was for some years the designing engineer of the Bigelow Co. The riveted joint has been one of his specialties, and diagrams for the designing of such joints contributed by him to "Power" some years ago attracted favorable attention. Further study has simplified the diagrams, and the recognition by the A. S. M. E. Code of only one value each for tensile, crushing and shearing strengths has made it possible in 75 plates to cover every form of joint with which a designer is likely to be called upon to deal. The simplicity of these diagrams and the ease of their use are evident from the instructions. "Select the diagram for the type of joint and the rivet-hole size required. Follow down to the vertical line representing the given pitch of rivet until it intersects a line representing the given plate thickness. The horizontal line passing through this point indicates the efficiency." The charts are drawn upon so large a scale that 1 per cent. of efficiency is represented by a space of about $\frac{3}{16}$ of an inch, so that they may be easily read to the first place of decimals. The manner in which the joint should fail is indicated by that section of the diagram in which the point of intersection lies.

In designing joints the maximum practical joint efficiency can be determined directly from the diagram, and the effect of varying size or pitch of rivets, or plate thickness, is apparent at a glance. Lines are added to indicate the maximum pitches which will permit tight calking, and the minimum pitches which can be used without interference in driving. A special diagram at the end of the series gives the bursting pressures and the safe working pressures, with a factor of safety of 5 for different diameters and joint efficiencies.

While the main value of the book lies in the diagrams, the 77 pages of reading matter which accompany them constitute at the same time the simplest and most satisfactory exposition of the principles involved, both in the joints and their diagrammatic representation, that we have seen. This portion of the work is illustrated by 52 engravings and carries a number of tables. It is indicative of the condensed form in which the matter is presented, that in these 77 pages 11 chapters are presented. These treat successively of Methods of Joint Failure; Types of Boiler Joints; Efficiencies of Boiler Joints; Boiler Plate Material; Strap Thicknesses and Rivet Diameters; Limiting Pitches; Boiler Joint Diagrams; Making Joint Diagrams; Riveted Joints of Maximum Efficiency. The author brings out the interesting fact, known perhaps to mathematicians but not generally understood, that by fixing the tensile and crushing strength of the plate material the possible maximum efficiency that may be obtained with each of the different types of joints is fixed; that is, with these two factors entering the calculation of the strength of riveted joints fixed, the highest efficiency that may be obtained with any given arrangement of rivets does not vary. This efficiency is indicated by the expression $E = \frac{RC}{RC + T}$, where R = the number of rivets in a unit section, C the crushing and T the tensile strength.

Law To Encourage Municipal Power Plants

An interesting measure is being considered by the Pennsylvania State Legislature, introduced in the Senate by Senator Charles A. Snyder on Feb. 13, covering the acquisition and operation of utilities by municipalities, particularly relating to electric-power stations and water systems. The proposed law provides that any city, borough or town in the state may lease from a private company the electric light, heat and power plant or water-works furnishing service to the community, or any such plant in the vicinity, with terms of agreement and length of period acceptable to both parties. The property so acquired is to be considered in all respects as though purchased by the municipality, and operated and conducted under the jurisdiction of the municipal officials. The establishment of rates also is left to the judgment of the municipal council or commission, such to be justifiable charges based upon the costs of operating the station and supplying service.

This compromise between municipal and corporate-owned power plants and other utilities is expected to eliminate dissensions and controversies, effecting an equitable basis for the operation of power stations by municipalities when deemed advisable by residents.

PERSONALS

F. Roberts, for nine years sales manager of the Reliance Gage Column Co., Cleveland, Ohio, is now president of the Ohio Steam Specialty Co., Cleveland, Ohio.

Grant Whittlesey continues as manager of the Philadelphia branch of the Strong, Carlisle & Hammond Co. instead of as might otherwise be inferred from the personal regarding H. B. Hill in our issue of Feb. 20.

J. Walter Allen has recently been appointed electrical engineer of the Boston Elevated Ry. Mr. Allen is a graduate of the Massachusetts Institute of Technology, class of 1899, and has been employed by the Boston company throughout his entire career, having filled every post in the electrical department from cable tester to acting electrical engineer.

A. H. Poehlman, formerly with the Combustion Appliances Co., of Chicago, and well known in the combustion field, is now with the Paul B. Huyette Co., of Philadelphia, in the combustion engineering department. One of the new features of this department will be a marine branch, which will specialize in the application of combustion appliances aboard ship.

Farnham Yardley, son-in-law of the late Alfred B. Jenkins, of Jenkins Bros., and formerly vice-president, was elected president of the company to fill the vacancy caused by the death of Mr. Jenkins. Frank T. Swain, general manager of the company, was elected vice-president. Samuel Laird, manager of the Philadelphia business, has been elected a director to fill the vacancy in the board.

ENGINEERING AFFAIRS

The Engineering Society of Buffalo will hold a special meeting on Wednesday evening, Mar. 7, at the Hotel Statler, at which Dr. Ira N. Hollis, president of the American Society of Mechanical Engineers, will speak on "Service to the Country in This Crisis." No dinner will be served preceding Dr. Hollis' address.

The New York Section A. S. M. E. at its monthly meeting on Tuesday evening, Mar. 13, will listen to an illustrated talk on "Mobile Armaments" by Andrew M. Coyle, mechanical engineer, with the Coast Defense Board of Engineers, U. S. A. As usual the meeting will be held at the Engineering Societies' Building, 29 West 39th St., at 8:15 p.m.

The Third Annual Industrial Safety Exposition of Ohio will be held at Memorial Hall, Columbus, from Mar. 6 to 10 inclusive, under the auspices of the State Industrial Commission. The formal opening will be held on Tuesday, Mar. 6, at 8:15 p.m., under the patronage of Gov. James M. Cox. The exposition will be devoted to the presentation and demonstration of apparatus and methods for the saving of lives and limbs in the industrial struggle.

The American Institute of Steam Boiler Inspectors of New York City held its seventh annual banquet on Saturday evening, Feb. 24, at the Marlborough Hotel, New York. It was attended by more than one hundred members and guests, and for the number in attendance and excellence of the entertainment, under the skillful guidance of M. Fogarty as toastmaster, the occasion surpassed all previous social sessions of the organization. Addresses were made by T. T. Parker, president, and L. A. Turnbull, the retiring president, who was presented with a gold enameled badge bearing the emblem of the Institute. Short addresses were made also by Dr. D. S. Jacobus of the Babcock & Wilcox Co., Col. F. W. Bigelow of the Bigelow Co., Franklin Van Winkle of "Power," W. S. Wilding of the International Filter Co., Messrs. T. G. Ranton and A. Oldfield of the Boston Institute of Steam Boiler Inspectors, G. E. Lanagan, Examiner of the Police Dept. Boiler Squad, and other speakers. President Parker extended a cordial invitation to all present to attend the next regular monthly meeting of the Institute which will be held at the Engineering Societies' Building, 29 West 39th St., New York, Friday evening, Mar. 30.

THE COAL MARKET

MARKET CONDITIONS

The market is hinging entirely on transportation conditions. Until the congestion is relieved and free movement obtained, high spot prices will be the rule, in spite of the approach of summer. Contracting is stagnant, consumers generally refusing to meet the high prices demanded, though many would meet these figures on short-term business, say three to six months.

Boston—Current quotations per gross ton delivered alongside Boston points as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	Mar. 3, 1917	One Year Ago	Mar. 3, 1917	One Year Ago
Buckwheat	$3.40@4.40	$3.05@3.20	$5.85@5.35	$3.25@3.50
Rice	2.90@3 90	2.50@2.65	.....	2.70@2.95
Boiler	2.75@3.75	.....	4.50@5.00	.....
Barley	2.65@3.65	2.20@2.35	4.35@4.90	2.35@2.60

BITUMINOUS

Prices per gross ton for Boston delivery are as follows:

	F.o.b. Mines*		Alongside Boston†	
	Mar. 3, 1917	One Year Ago	Mar. 3, 1917	One Year Ago
Clearfields	$5.60@6 50	$1.75@2.40	$10.25@10.50	$4 25@5.00
Cambrias and Somersets	5.90@7.00	1.90@2.65	10.50@11.00	4.60@5.40

Pocahontas and New River, f.o.b. Hampton Roads is $7@7.25, as compared with $2.80@2.90 a year ago; on cars Boston price is $13@15, against $6@6.25 a year ago.

*All-rail rate to Boston is $2 60. †Water coal.

New York—Current quotations per gross ton f.o.b. Tidewater at the lower ports as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	Mar. 3, 1917	One Year Ago	Mar. 3, 1917	One Year Ago
Buckwheat	$2.75	$2.75	$6 75@7.25	$3 00@3.25
Rice	2.20	2.25	5.00@5.50	2.40@2.50
Barley	1.95	1.75	4.25@4.50	1.80@2 00

Quotations at the upper ports are about 5c. higher.

BITUMINOUS

	South Amboy		Port Reading	Mine Price	
	Mar. 3, 1917	One Year Ago	Mar. 3, 1917	Mar. 3, 1917	One Year Ago
Clearfield	$7.75@8.00	$3.25@3.50	$7.75@8.00	$6.25@6.50	$1.70@1.95
South Forks	7.75@8.00	3.50@3.75	7.75@8.00	6.25@6.50	1.95@2.20
Nanty Glo	7 75@8.00	3.35@3.60	7.75@8.00	6.25@6.50	1.80@2.05
Somerset	7.75@8.00	3.25@3 50	7.75@8.00	5.75@6.00	1.70@1.95
Quehamoning	7.75@8.00	3.45@3.60	77.5@8.00	6.00@6.25	1.90@2.05

The lower ports are: Elizabethport, Port Johnson, Port Reading, Perth Amboy and South Amboy. The upper ports are: Port Liberty, Hoboken, Weehawken, Edgewater or Cliffside and Guttenberg. St. George is in between and sometimes a special boat rate is made. Some bituminous is shipped from Port Liberty. The freight rate to the upper ports is 5c. higher than to the lower ports.

Philadelphia—Prices per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide shipment are as follows:

	Line		Tide	
	Mar. 3, 1917	One Year Ago	Mar. 3, 1917	One Year Ago
Buckwheat	$2.50	$1.55	$3 40	$2.30
Rice	2.10	.90	3.00	1.80
Boiler	1.95	....	3.15	....
Barley	1.85	.55	2.05	1.30

Pittsburgh—Price of steam coal per net ton f.o.b. mine, Pittsburgh district:

	Mar. 3, 1917	One Year Ago
Slack	$5.00@5.25	$1.15@1.20
Mine-run	5.25@5.50	1.25@1.30
¾-in.	5.25@5.50	1.35@1.40

Add 40c. per ton for freight charge to Pittsburgh.

Chicago—Current price per net ton f.o.b. mines are as follows:

	William-son and Franklin Counties	Saline and Harrisburg	West Virginia Smokeless	Spring-field	Clinton and Sullivan Counties
Steam lump	.....	$3.50@3.75	.....	$3.25@3.50	$3.00@3.50
Lump	$3.75@4 00	3.75@4.00	$5.00@5.25	3.50@3.75	3.50@4.00
Egg	3.75@4.00	3.75@4.00	5 00@5.25	3.25@3.50	3.25@3.75
Nut	.....	3.75@4.00	.....	3.25@3.50	3.00@3.50
No. 1 nut	3.75@4.00	.....	.....	.....	.....
No. 2 nut	3.75@4.00	.....	.....	.....	.....
No. 3 nut	3.50@3.75	.....	.....	.....	.....
No. 1 washed	3.75@4.00	.....	.....	.....	.....
No. 2 washed	3.75@4.00	.....	.....	.....	.....
Mine-run	3.50@3.75	3.50@3.75	4 75@5.00	3.00@3.25	2 75@3 25
Screenings	3.50	3.25@3.50	.....	2.50@2.75	2.50@2.75

Hocking lump, $4.50@4 75; splint lump, $4.50@4.75.

St. Louis—Price per net ton f.o.b. mine a year ago as compared with today are as follows:

	Williamson and Franklin Counties		Mt. Olive and Staunton		Standard	
	Mar. 3, 1917	One Year Ago	Mar. 3, 1917	One Year Ago	Mar. 3, 1917	One Year Ago
6-in. lump	$3.25	$1 60@1.75	$2.85	$1.35@1.50	$2.50@2 60	$1 10@1.25
2-in. lump	3.00	1.40@1.50	2.75	1.25@1.35	2.35@2.50	.95@1.10
Steam egg	3.00	1.60@1.65	2 75	1.25@1.30	2.35@2.50	.90@1.10
Mine-run	3.00	1.10@1.20	2.50	1.10@1.15	2 25	.90@1.00
No. 1 nut	3.25	1.35@1 50	2.50	1.15@1.25	2 35@2.50	.95@1.10
2-in.screen.	2.50@2.75	.90@1.00	2.15@2.25	.75@ .90	2.05@2.15	.70@ .85
No. 5 washed.	250	.90@1.00	2.00	.75@ .85	2.00	.70@ .85

Williamson-Franklin rate St. Louis, 72½c.; other rates, 57½c.

[1]Individual prices are the company circulars at which coal is sold to regular customers irrespective of market conditions. Circular prices are generally the same at the same periods of the year and are fixed according to a regular schedule.

PROPOSED CONSTRUCTION

Ala., Birmingham—City plans to issue $500,000 bonds to install an electric-light plant.

Calif., Hanford—The Hanford Gas and Power Co. will improve its system and install new machinery. Estimated cost, $30,000.

Conn., Middletown—The Franklin Electric Co. will extend its plant on Hamlin St.

Ga., Unadilla—City will construct an electric-light plant.

Ind., Tipton—City will improve the electric-light plant. Estimated cost, $12,500.

Ia., Cumberland—City voted vonds to install an electric-light plant.

Ia., Grinnell—Grinnell College is having plans prepared for an addition to its power plant. Pillsbury Engineering Co., Metropolitan Bldg., Minneapolis, Engr.

Kan., Osage—City will install a transmission line from the electric-light plant to Allen and Admira.

Kan., Yates Center—City plans to issue $30,000 bonds to install an electric-light plant.

Ky., Cave City—The Kentucky Utilities Co., of Louisville, will construct an electric transmission system from Glasgow to Cave City and Horse Cave. A. Boyd, Local Supt.

La., Monroe—City will hold an election Mar. 20 to vote on $61,000 bonds to build a power house and rebuild its electric generating plant. W. G. Kirkpatrick, Jackson, Miss., Engr.

Mich., Detroit—The Detroit Edison Co. will construct a 6-story heating plant at 91-105 West Congress St. Estimated cost, $156,000.

Mich., Lowell—The City Council is having plans prepared for an addition to its electric-light plant. F. S. Williams, Ann Arbor, Engr.

Mich., Yazoo City—City will improve the electric-light plant. Estimated cost, $20,000.

Minn., Benson—The City Council is having plans prepared for remodeling the electric-light plant. W. E. Skinner, 714 Plymouth Bldg., Minneapolis, Consult. Engr.

Minn., Crosby—City will install an electric-light plant.

Minn., Emmens—City will construct an electric-light plant. E. D. Jackson, Capitol Bank Bldg., St. Paul, Consult. Engr.

Mo., Marshall—City will install an electric-light plant. Estiamted cost, $75,000. Henrici, Kent & Lowry, 222 Commerce Bldg., Kansas City, Engr.

Mo., Poplar Bluff—City plans to issue $10,000 bonds to install an electric-light system.

N. J., Bayonne—Public Service Electric Co. will construct an addition to its plant at 36th St. and Broadway. N. A. Carle, Newark, Ch. Engr.

N. Y., Geneva—City will install an electric-light plant.

N. J., Jay—Paul Smith's Electric Light, Power and Railroad Co. has applied to the Public Service Comn. for permission to instal an electric-distributing system. P. Smith, Pres.

N. Y., Newport—The Newport Electric Light and Power Co. will extend its transmission lines. G. T. Woodlin, Treas.

N. Y., New York—(Borough of Manhattan)—Dept. of Health has had plans prepared for a 1-story, 47x104-ft. boiler house. H. Emerson, Center and Walker St., Comr. W. E. Austin, 46 West 24th St., Arch.

N. Y., New York—(Borough of Manhattan)—New York Central Railroad Co., 45th St. and Lexington Ave., has had plans prepared for a heating plant at 43rd St. and Lexington Ave. Estimated cost, $175,000. J. G. Wise, Grand Central Terminal, Arch.

Ohio, Kent—The Northern Ohio Traction and Light Co., Akron, is having plans prepared for the rebuilding of its electric-light plant. R. Harter, Akron, Pur. Agt.

Ohio, Lancaster—The State Legislature has appropriated $100,000 for a power house at the Boys' Industrial School.

Ohio, Leipsic—The Northwestern Ohio Light Co. will install a power plant. Estimated cost, $40,000. The plant will supply electricity to Hamler and Oakwood.

Ohio, Scott—City plans to install an electric-light plant.

Ohio, Youngstown—The Youngstown & Sharon St. Railway Co. will construct an electric-light plant. F. H. Bell, Youngstown, Mgr. Lighting.

Okla., Altus—City plans a transmission line from Altus to Duke.

Okla., Billings—City will soon hold an election to vote on $50,000 bonds for an electric-light plant for which plans are being prepared. Mackintosh Walton Engineering Co., 1025 State National Bank Bldg., Oklahoma, Engr.

Okla., Lawton—The Night and Day Oil Co. will rebuild its power plant and pumping station which was recently destroyed by fire.

Ont., Delaware—City voted in favor of a by-law to install a hydro-electric system. Estimated cost, $50,000.

Penn., Lewistown—The Penn Central Light and Power Co., Altoona, will install a transmission line from Lewistown to Warriors Ridge. H. A. Crownover, Altoona, Pur. Agt.

R. I., Pawtucket—The Pawtucket Glazed Paper Co. will construct a 30x50-ft. brick boiler house and will install a 130-hp. boiler.

Wis., Amberg—City will construct a hydro-electric power plant to supply the city and the neighboring towns with light and power.

Wis., Osceola—The Osceola Mill and Elevator Co. has had plans prepared for a hydro-electric power plant. Power Engineering Co., Corn Exchange, Minneapolis, Engr.

Wis., Union Grove—The Union Grove Electric Light and Water Co. will rebuild its plant which was recently destroyed by fire. W. Hardy, Owner.

Prices—Materials and Supplies

ELECTRICAL SUPPLIES

Knife Switches—Following are net prices each in New York for knife switches mounted on slate base, front connected, punched clip type:

	30 Amp.	60 Amp.	100 Amp.	200 Amp.
Double pole, single throw, fuseless	$0.76	$0.88	$1.80	$3.24
Double pole, single throw, fused..	.76	1 30	2 63	4.86
Double pole, double throw, fuseless	1.22	1.44	3.24	5.40
Double pole, double throw, fused..	1.58	2.45	5.33	9.36
Triple pole, single throw, fuseless.	1.15	1 32	2.71	4.87
Triple pole, single throw, fused...	1.15	1.94	3.96	7.30
Triple pole, double throw, fuseless.	1 91	2.23	4.97	8.35
Triple pole, double throw, fused...	2.53	3.92	8.52	14.98

Lots $25 and more, list.

Fuses—Following are net prices in New York in standard packages:

	0-30	31-60	61-100	110-200	225-400
Fuse plugs, per 100.....	$4 20	....	....	....	....
Enclosed fuses, each.....	.1275	$0.18	$0.46	$1.02	$1.84

Standard package fuse plugs, 500; cartridge 3-60, 100; 65-100, 50; 110-400, 25. Fuse plugs less than package, 5c. each.

Sockets—Following are net prices per 100 in New York for standard packages:

	Package	Key	Keyless	Pull Chain
⅛-in. cap	500	$20.75	$18.80	$37.70
⅜-in. cap	250	28.08	25 92	47.52
Pendant cap ⅛-in.....	250	20.75	18.80	37.70
Less than package in ⅛ and pendant and more than 25, each.....		.22	.20	.10

Cut Outs—Following are net prices in New York for standard package quantities:

	Edison Plug	Cartridge Fuse		
	Packages 0-30	0-30	31-60	61-100
Double pole, main line.....	50 $0.165	$0.3025	$0.77	$1.54
Triple pole, main line.....	50 .242	.44	1.10	2.20
Double pole, single branch.....	50 .176	.385	.965	...
Triple pole, single branch.....	50 .297	.7425	1.65	...
Double pole, double branch.....	25 .341	.715	1.925	...
Triple pole, double branch.....	25 .495	1.2375	3.30	...
Three- to two-wire, double branch	25 .352	.825	2 31	...

Copper Wire—Following are prices in New York for rubber-covered wire in standard quantities of 1,000 ft.:

	Jan. 30, 1917		
No.	Single Braid	Double Braid	Duplex
14	$13.50	$14.90	$25.56
12	17.70	19 70	38.65
10	24 30	26.75	52.70
8	34.50	37 12	73.60
6	54.05	58.55	....
5	72.10	77.60	....
4	48.80	92.40	....
3	104.10	110.00	....
2	125.00	132 00	....
1	162.00	170.50	....
0	223.00	223 00	....
00	267.50	267 50	....
000	328.00	328.00	....
0000	403.50	403.50	....

Lamps—Below are present quotations in less than standard package quantities::

Straight-Side Bulbs				Pear-Shape Bulbs			
Mazda B—			No. in	Mazda C—			No. in
Watts	Plain	Frosted	Package	Watts	Clear	Frosted	Package
10	$0.27	$0.30	100	75	$0.65	$0.70	..
15	.27	.30	100	100	1.00	1.05	24
25	.27	.30	100	300	3.00	3.10	24
40	.27	.30	100	500	4.50	4.65	12
50	.28	.31	100	750	6.00	6.25	8
60	.36	.40	100	1,000	7 00	7.25	8

Standard package quantities are 10% from above prices. Yearly contracts ranging from $150 up allow a discount of 17% from list, with corresponding discounts for larger contracts.

Separable Attachment Plugs—Following are prices in New York:

Porcelains, standard package 250, each.....	$0.21
Composition, standard package 250, each.....	.28
Side outlet, current taps, standard package 50, each.....	35

Cord—Following are prices in New York in cents per foot:

	Coil, Ft.			Coil, Ft.	
No. 18 cotton, parallel....	250	2.83	¼-in. loom	250	3.00
No. 16 cotton, parallel....	250	3 65	⅜-in. loom	250	4 50
No. 18 cotton, reinforced.	250	4.07	½-in. loom	200	6.00
No. 16 cotton, reinforced.	250	4.86	⅝-in. loom	200	7.50
No. 18 canvasite.....	250	3.17	¾-in. loom	150	9.00
No. 16 canvasite.....	250	3 88	1 -in. loom	100	12.50
			1¼-in. loom	100	16 50
			1½-in. loom	100	20.00

Locknuts and Bushings—Following are net prices in New York in standard packages, which are: ½ in., 1,000; ¾ to 1¼ in., 100; 1½ to 2 in., 50:

In.	Locknuts Per 100	Bushings Per 100	Flexible Conduit Box Connections Per 100
½	$1.02	$1.68	$5.62
¾	1.75	4.00	7.12
1	3.00	6.15	10.50
1¼	5.00	8.20	15.00
1½	7.50	10.25	22 50
2	10.00	16.40	30 00
2½	12.30	24.60	67.50

Conduit—Following are net prices in cents per ft. in New York in 1,000-ft. lots:

In.	Rigid	Flexible	In	Rigid	Flexible
½	$4.69	$9.37	1½	16.22	23.80
¾	6.78	8.84	2	21.83	30.60
1	10.03	14 28	2½	34.51	35.36
1¼	13,27	17 68			

Standard lengths rigid, 10 ft. Standard lengths flexible, ½ in., 100 ft. Standard lengths flexible, ¾ to 2 in., 50 ft

Conduit Couplings—Following are net prices in New York in standard packages:

	Per 100			Per 100	
In	Rigid	Flexible	In	Rigid	Flexible
½	5.18	6.80	1½	$15.12	$22.56
¾	6.70	12.00	2	20.16	30.00
1	8.71	15.75	2½	28.80	45.00
1¼	12.24	15.75			

Armored Cables and Box Connectors—Following are net prices in New York per 1,000 ft. cable and standard package of 100 box connectors in single and double strip:

	Twin Conductor		Three Conductor	
Wire Gage	Cable	Connectors	Cable	Connectors
14	$75.00	$4 50	$106.26	$3.75
12	103.95	4.50	130.90	3.75
10	142.45	4.50	180.95	3.75
8	180.95	4 50	250.25	3.75
6	284.90	5.70	363.44	7.00
4	442.75	8.40	.....	....

Standard lengths per coil—Nos. 14 to 10, 150@250 ft.; Nos. 8 to 4, 100@150 ft.

MISCELLANEOUS

Hose—

Fire	50-Ft. Lengths
Underwriters', 2½-in	55@60c. per ft.
Common, 2½-in	60% from list

Air	First Grade	Second Grade	Third Grade
¾-in., per ft.....	$0.45	$0.25	$0.18

Steam—Discounts from list

First grade..... 33⅓% Second grade..... 40% Third grade..... 50%

Rubber Belting—The following discounts from list apply to transmission rubber and duck belting:

Competition ..... 60% Best grade 30%
Standard 50%

Leather Belting—Present discounts from list in New York are as follows:

Medium grade..... 40—5% Heavy grade..... 35—5%

Packing—Below are prices per pound, New York City:

Asbestos

Valve and Stuffing Box	Twisted plain, 25-lb. cartons.....	$0.65@.70
	Twisted graphite, 25-lb cartons.....	.80
	Braided plain, 25-lb. cartons.....	.90
	Braided graphite, 25-lb. cartons.....	1 00
Asbestos wick in balls, ¼, ½, 1 lb., 25- and 50-lb. cartons.....		.65@.70
Rubber asbestos, compressed sheet, medium grade, about.....		.80

Steam

Following in 25- and 50-lb. cartons:

First grade ..... $0.75 Second grade $0.50

Rubber and Duck

Higher grade ..... $0.40 Cold water $0.25

Piston

Asbestos, duck and rubber... $1.25 Rubber and duck..... $0 90
Flax first grade..... .85

Greases—Price in New York in cents per pound for barrel lots:

Cup ..... 5@7c Axle ..... 3@4c
Fiber or sponge..... 5@7c. Gear ..... 4@5c.
Transmission ..... 5@7c. Car journal (S & F)..... 6½c

Fuel Oil—Price in cents per gal. at Eastern terminals in bbl. lots:

Domestic light, 22-26 Baumé..... 5½@6
Mexican heavy, 12-14 Baumé..... 4½@5

Eastern terminals are Boston, Providence, Bayonne, Philadelphia, Baltimore and Norfolk.

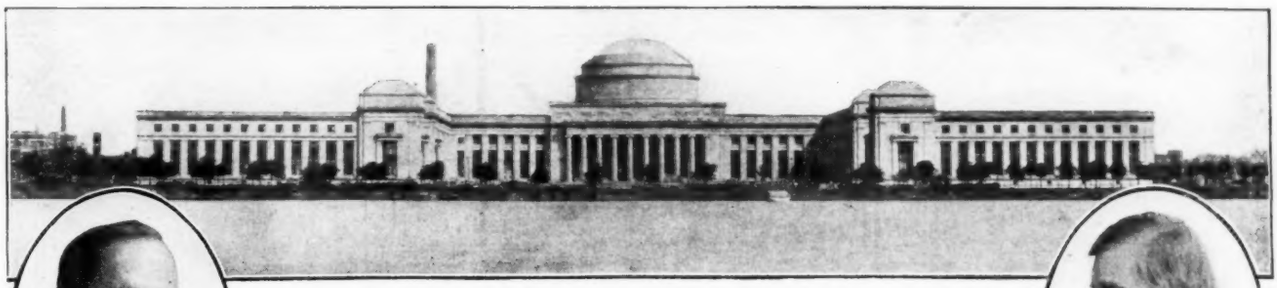
Cold Drawn Steel Shafting—From warehouse to consumers requiring fair-size lots, the following quotations hold:

	Jan. 30, 1917	Six Months Ago
New York	List plus 20%	List plus 20%
Cleveland	List plus 20%	List plus 20%
Chicago	List plus 5%	List price

Fire Brick—Quotations on the different kinds are as follows, f o b. works, eastern Pennsylvania:

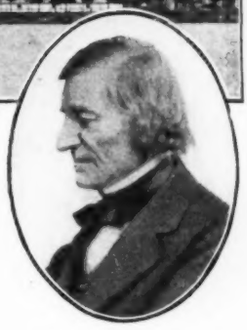
Silica brick, per 1,000.....	$40.00@ 50.00
Fire clay brick, per 1,000.....	35.00@ 40.00
Magnesia brick, per net ton.....	135.00@140.00
Chrome brick, per net ton.....	125.00@135.00
Deadburned magnesite brick, per net ton.....	85.00@ 90.00
Special furnace chrome brick, per net ton.....	60.00@ 70.00

Standard size, 9x4½x2½ in. The second quality is $4 to $5 cheaper per ton



RICHARD C. MacLAURIN, President

WILLIAM BARTON ROGERS, Founder



Technology's Laboratories and Power Plant

By Charles H. Bromley

SYNOPSIS—Describes the chief features of equipment of the engineering laboratories and power plant of the Massachusetts Institute of Technology, Cambridge, Mass.

There is, perhaps, no institution of its kind that has the beauty and magnitude of "New Tech." For the engineering laboratories alone an area of 75,000 sq.ft. is used. These laboratories may be divided as follows: Steam, hydraulic, steam-hydraulic machinery, heat treatment, heat transmission, gas, compressed air, power measurement, refrigeration, strength of materials, and cement and concrete. The equipment is complete not only for purposes of instruction but for research work, much of which Technology carries on most all the time. The departments of chemistry, mining, physics, electrical engineering and sanitation have their own laboratories.

The engineering laboratory occupies the basement, first and second floors of what is known as Buildings Nos. 1 and 3 and 9. It should be pointed out that one of the good things about "Tech" is that the students may go from building to building without having to go out-of-doors. The heavy machinery is of course in the basement, while the lighter apparatus is on the other floors. One gets a good idea of the general layout from Fig. 1. Notice the fine lineshaft arrangement along the wall. The writer was also impressed with the piping. This work is so neatly done as to be really pleasing to the eye and is so placed that it is not in the way of the students.

Identifying Colors for Piping

In a large institution like "Tech," with so many students, instructors and members of the institute's engineering force, it is vital that no mistakes be made either in locating or quickly distinguishing the different pipe lines and valves. Each pipe line is painted a distinguishing color, the lines and their respective colors being as follows:

COLORS FOR PIPING

Water	
Hydraulic pipes in the experimental laboratory	Emerald green up to 100 lb., above 100 lb. green, white fittings
City water pipes	Light blue
Filtered water	Light yellow
Steam	
High-pressure steam pipes	White and black
Atmospheric exhaust pipes	Orange
Intermediate steam pressure (60 lb.)	White pipe, orange fittings
Exhaust pipes, vacuum	Orange, red fittings
High-pressure drips	Oxide red
Intermediate-pressure drips	Oxide red, black fittings
Low-pressure drips	Oxide red, orange fittings
Air	
Compressed air (8 lb.)	Light drab
Compressed air (80 lb.)	Light drab, black fittings
Vacuum sweeper pipes	Slate
Chemical blast pipes	Drab
Chemical suction pipes	Light brown
Gas	
Gas pipes	Maroon
Refrigeration	
Brine pipes	Ultramarine blue
Ammonia pipes	Black
Miscellaneous	
Sulphuretted hydrogen	Light green
Cast-iron sanitary pipes	White, black fittings
Cast-iron laboratory pipes	Van Dyke brown

The Hydraulic Laboratory

While by no means the most important, the hydraulic laboratory is the most impressive. The institute is on the bank of the Charles River, and river water feeds the 700 ft. of 5 ft. deep concrete canals in the laboratory through 14-in. cast-iron pipe. The three canals are 5 ft. deep, one being 8 ft. wide, one 5 ft. wide, and the other 3 ft. wide, leading from a reservoir at one end. The smaller canal is tapped off into two 26-ft. sumps with 16-in. and 3-in. special filling valves. The pulsometer and triplex pumps in Fig. 2 are over these sumps. The canals also make an ideal arrangement for the intake and discharge for the steam condensers. A good view of one of these canals is had from Fig. 4. This picture shows three weir boxes overhead, which receive the discharge from Pelton waterwheels located on the floor above and shown at the left background, Fig. 10. Over the canals, Fig. 4, is a large weir box 6 ft. wide by 4 ft. deep, which discharges water from a Warren high-pressure pot-valve plunger pump, Fig. 5, located in another part of the laboratory.

Fig. 3 shows the 30-in. Worthington centrifugal pump driven by an American Ball engine. This pump has, under low heads, a capacity of 30,000 gal. per min., and 22,000 gal. per min. under 40 ft. head. It discharges through a 30-in. venturi meter. The pump discharges to the flume shown in Fig. 6. This flume is indeed impressive, as it is 135 ft. long, 5 ft. wide and 5 ft. deep. There is many a creek that does not flow as much water as may pass through this flume. So that the water from the pump willl reach the flume with least disturbance, the discharge pipe after leaving the venturi meter gradually

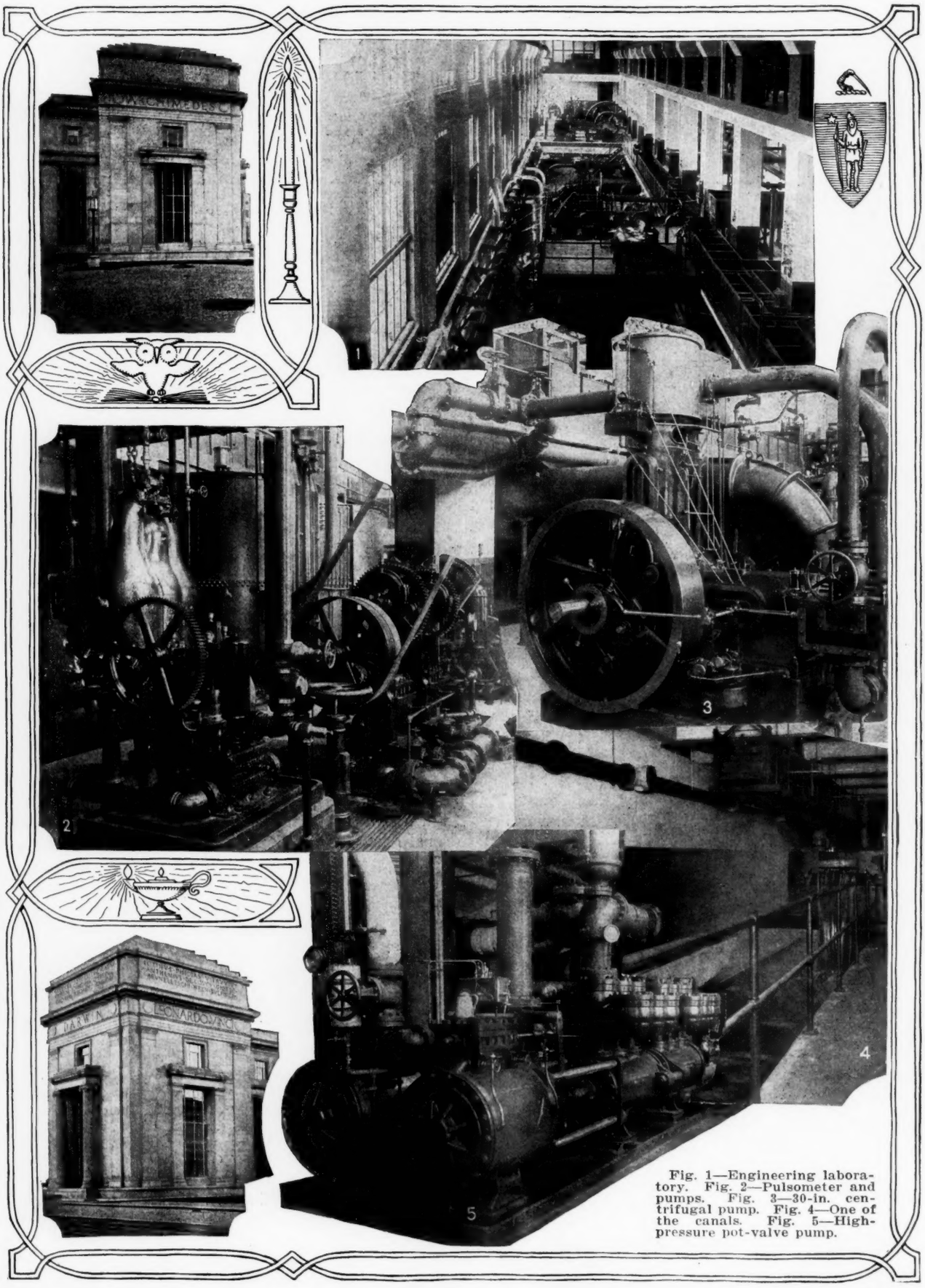
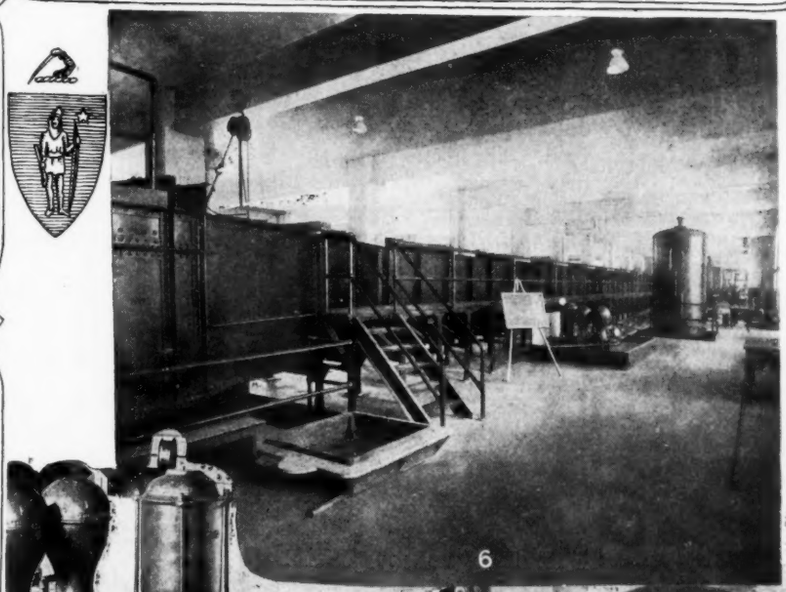
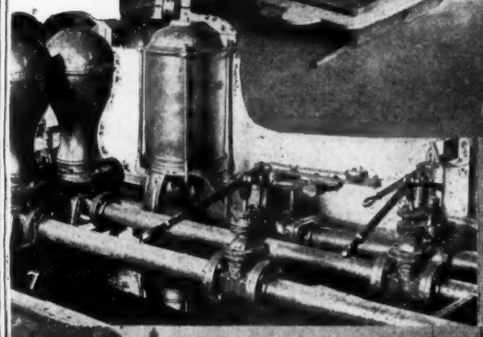
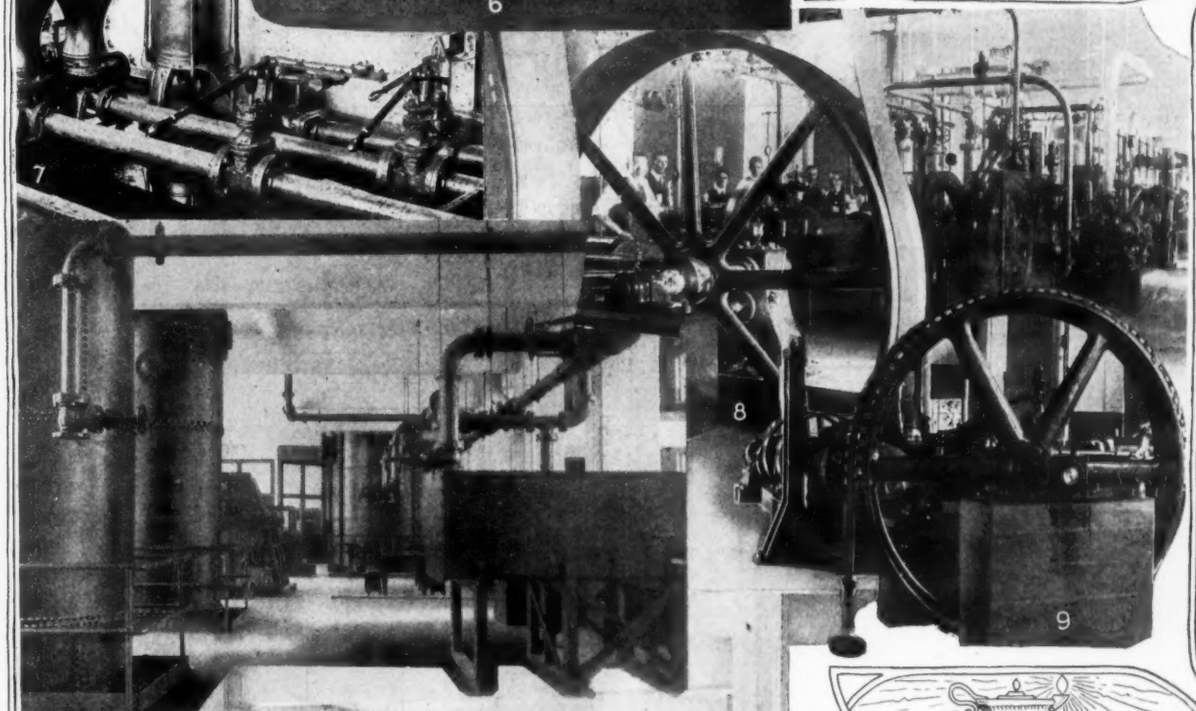


Fig. 1—Engineering laboratory. Fig. 2—Pulsometer and pumps. Fig. 3—30-in. centrifugal pump. Fig. 4—One of the canals. Fig. 5—High-pressure pot-valve pump.

SHOWING THE FOUR MEMORIAL TOWERS AND EQUIPMENT OF THE







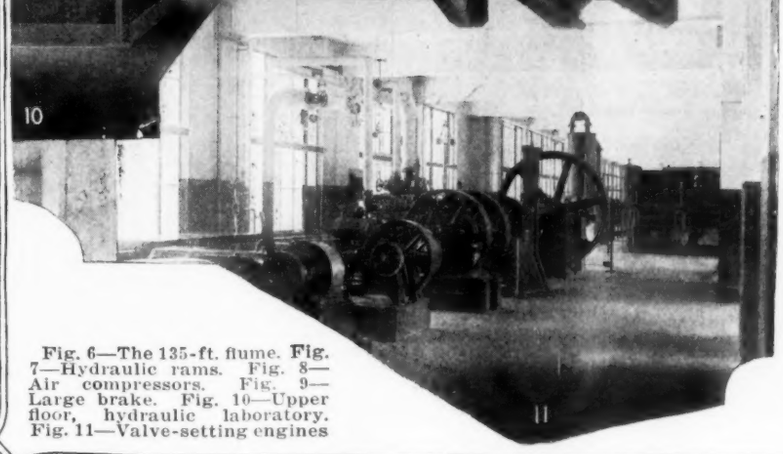


Fig. 6—The 135-ft. flume. Fig. 7—Hydraulic rams. Fig. 8—Air compressors. Fig. 9—Large brake. Fig. 10—Upper floor, hydraulic laboratory. Fig. 11—Valve-setting engines

ENGINEERING LABORATORIES, MASSACHUSETTS INSTITUTE OF TECHNOLOGY

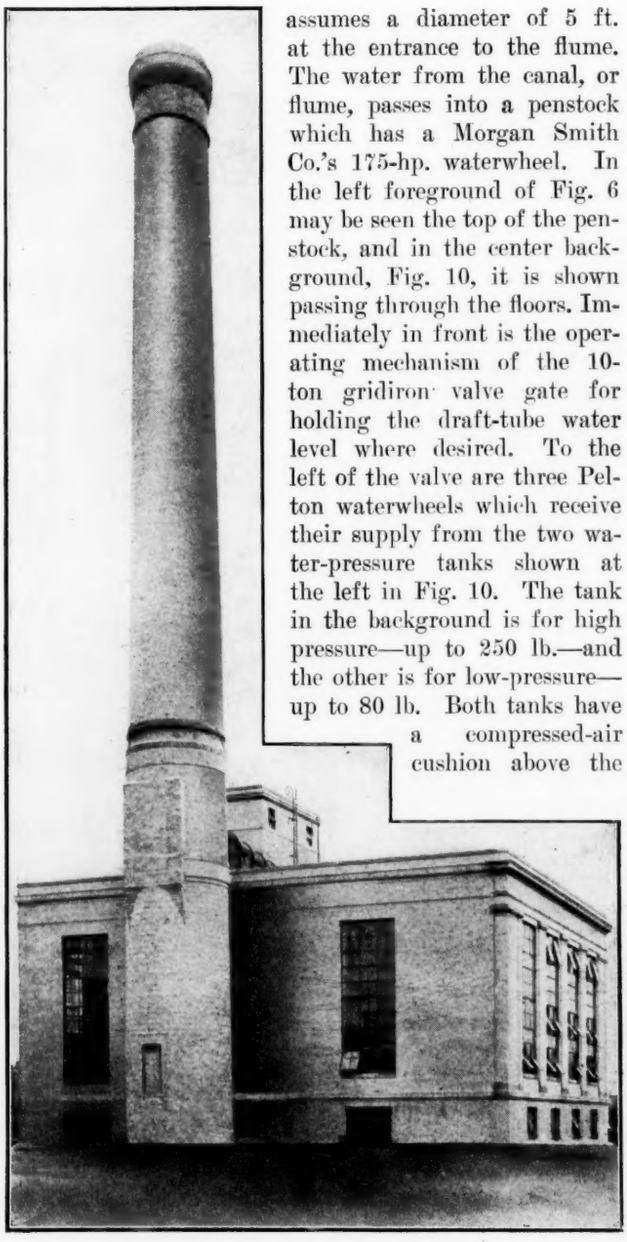


FIG. 12. EXTERIOR OF "TECH" POWER PLANT

assumes a diameter of 5 ft. at the entrance to the flume. The water from the canal, or flume, passes into a penstock which has a Morgan Smith Co.'s 175-hp. waterwheel. In the left foreground of Fig. 6 may be seen the top of the penstock, and in the center background, Fig. 10, it is shown passing through the floors. Immediately in front is the operating mechanism of the 10-ton gridiron valve gate for holding the draft-tube water level where desired. To the left of the valve are three Pelton waterwheels which receive their supply from the two water-pressure tanks shown at the left in Fig. 10. The tank in the background is for high pressure—up to 250 lb.—and the other is for low-pressure—up to 80 lb. Both tanks have a compressed-air cushion above the surface of the water in them to obtain a steady pressure. On the right, Fig. 10, are weir boxes which discharge into a trough which in turn discharges into calibrated tanks of such capacity that 1000 cu.ft. per min. of water may be handled continuously. As previously stated, the water is from the Charles River.

Fig. 5 shows the pot-valve plunger pump previously mentioned. This pump delivers 1500 gal. per min. at 250 lb. delivery pressure. High-pressure water for experiments is furnished by this pump, which, by the way, is connected with surface condensers. These tanks are each 10 ft. in diameter and 10 ft. high. They are equipped with 15-in. hydraulically controlled valves. Notice the pulsometer, Weber subterranean pumps, etc., above the sump covered by the grating in Fig. 2. There are two sumps here, each 26 ft. deep, arranged so that water may be bled into them from a middle sump through two 16-in. valves, each with a cone 16 in. long that enables fine regulation to be had. By this means any depth of suction may be maintained on a piece of apparatus under experiment. A near view of the hydraulic rams, right middle foreground of Fig. 6, is shown in Fig. 7.

For supplying water under pressure for hydraulic purposes there are the pot-valve pump, 30-in. centrifugal, another steam-driven centrifugal, three triplex and two duplex pumps, all cross-connected except the large centrifugal. Connections to this pump are made so that it may be used to flush the canal systems.

Fig. 11 shows several engines used chiefly for valve-setting instruction. A view of the compressed-air end of the laboratory is shown in Fig. 8. A close view of the large brake in Fig. 11 is shown in Fig. 9. This part of the laboratory contains four compressors of different standard makes and a three-stage compressor, compressing air to 2500 lb.

A 10-ton crane runs along the ceiling of the second floor, and half of the first and second floors are cut away for a length of nine columns to form a crane well. Large doors are provided in the basement, and a large truck may be backed in onto the basement floor to facilitate handling heavy pieces.

The machines in the testing-materials laboratory include: A 400,000-lb. universal Riehlé; 1,000,000-lb. Amsler-Laffon hydraulic compression machine; a 300,000-lb. Emery; a 200,000-lb. Olsen with extensions for transverse work; 150,000-lb. rope tester, as well as three 100,000-lb., a 60,000-, two 50,000- and a 20,000-lb. tension machines, and a 100,000-lb. beam machine. Each machine is served by a crane placed above it. Many smaller testing machines are on the floors above. On the third floor of this laboratory heat-treatment of metals is

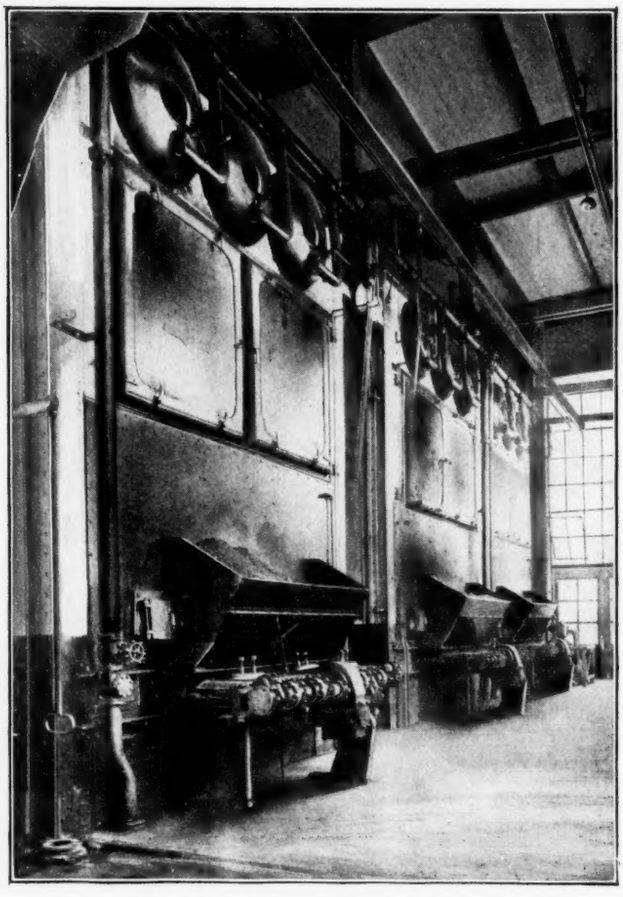


FIG. 13. VIEW OF PART OF THE BOILER ROOM

studied, furnaces, pyrometers, tempering baths, etc., being well provided.

Realizing the growing importance of a knowledge of heat transmission through various substances, the department of mechanical engineering is now fitting out a laboratory devoted exclusively to this work on a scale commensurate with these broad requirements.

The mechanical drawing rooms occupy all the fourth floor of the engineering laboratory building. Being a top floor with large skylights of opaque glass and large windows, the light is excellent. Illumination throughout the institute is direct-indirect.

That the Mechanical Engineering Department sees much for the future of refrigeration is evidenced by the provisions already made for extensions in this part of the laboratory. This laboratory will contain a 5-ton ammonia compressor, a 3-ton CO_2 machine and a 5-ton absorption system, together with six separate condensers, brine coolers, etc., arranged especially for heat-transmission experiments.

Much of the machinery in "New Tech" is from the old institute buildings over in Boston, and some of it could not, on account of its weight, be carried over the old Harvard Bridge, but had to be taken over the West Boston Bridge. A. S. Smith, chief engineer and superintendent of buildings, is to be congratulated on moving this machinery from old "Tech" with his own crew and getting it set up ready for the opening of "New Tech" in the short time of four months.

The steam-engine equipment has, besides the American Ball used on the large centrifugal pump, a triple-expansion Allis Corliss, having cylinders 9x16 in. and 24x30 in.; a McEwen tandem-compound 300-hp. and a McIntosh & Seymour tandem-compound 200-hp.; a Brown engine and a Westinghouse compound engine with a 125-kw. generator, a small Westinghouse turbine and a 75-kw. Curtis turbine. These are in the background of Fig. 1. There is also a separate laboratory now being fitted out, which is devoted entirely to power measurements. In this laboratory dynamometers, governors, balancing machines, machines for determining the critical speed of shafting, apparatus for testing fans, the transmission of power by belting, etc., are to be installed.

Besides all the foregoing, there is a gas laboratory in a separate building. This laboratory is an integral part of the department, but located down near the power house, so as to make it possible to exhaust aëroplane engines without muffling, which of course could not be done were the laboratory located near the main educational group. This laboratory is 40x70 ft., two stories in height and equipped with a 5-ton traveling crane suspended under the roof, a part of the second floor being omitted over an area approximately 20x40 ft. This building is to contain a 60-hp. producer, a 60-hp. gas engine, a 50-hp. Diesel engine, a 20-hp. International Harvester engine, a 36-hp. auto engine and numerous oil engines. A test block and a complete equipment on the second floor are to be used for testing aëro engines. There is now ready for setting enough apparatus to completely fill this laboratory.

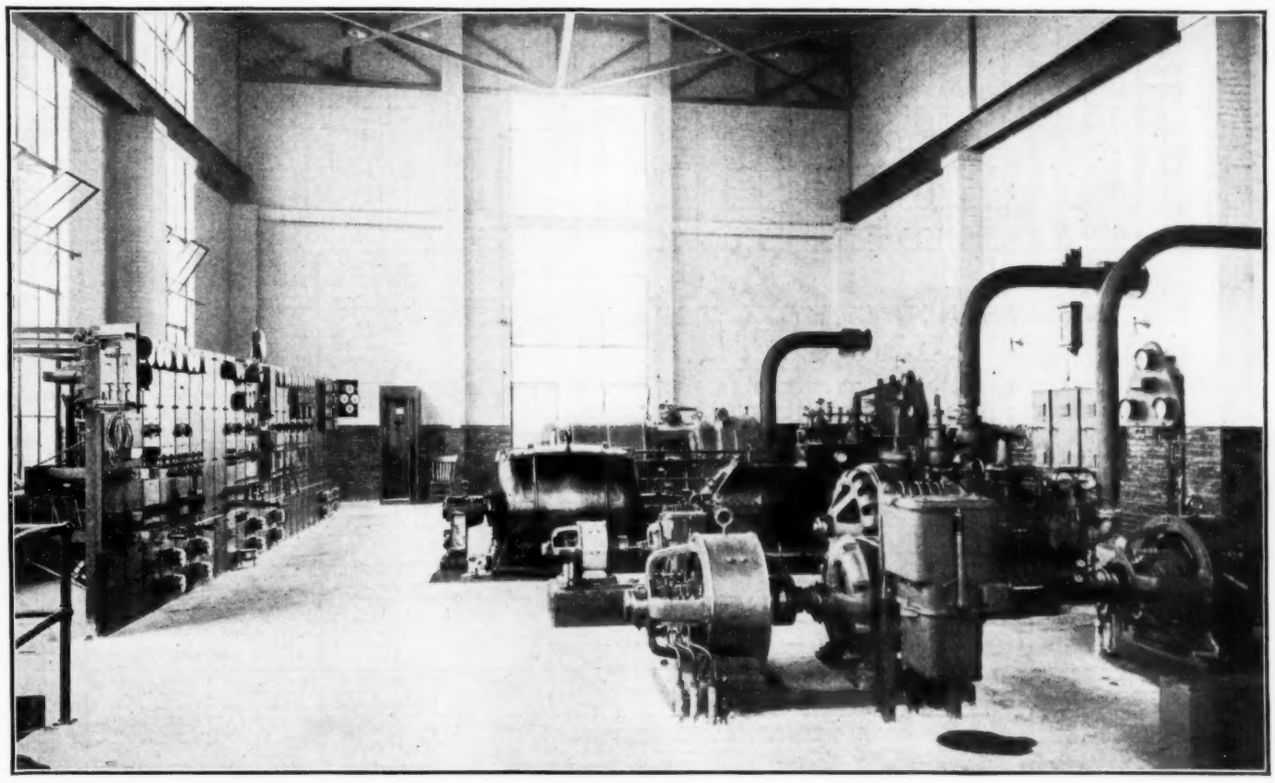


FIG. 14. SHOWING EQUIPMENT IN THE GENERATOR ROOM

The power plant is well provided with standard equipment neatly and conveniently arranged. As there is nothing unusual about it, the views, Figs. 12, 13 and 14, tell as much as might be said in text. There are three 520-hp. and one 200-hp. Babcock & Wilcox boilers, each having Riley stokers. The settings are such as to give 14 ft. from the floor line to the bottom of the headers. A coal larry used (Underwood) is not shown in Fig. 13. Balanced-draft, coal scales (Richardson) and steam-flow meters (General Electric) are used. The boiler leads

Weather **Watch Engineer** **Fireman**

Morning Watch .....

Afternoon Watch .....

Night Watch .....

MASSACHI

Time	Temperature: Outside	Feed: Cold	Feed: Hot	Steam	Pressures Gauge: High P.	Low P.	Secondary Pressures: Intermediate	Main Exhaust	Auxiliary Exhaust	Time Running: Boilers: No. 1	No. 2	No. 3	No. 4	Stoker Engines: 1	2	Turbine Fans: 1	2	Boiler Feed Pumps: 3	Terry	Terry	Warren	Venturi Water Meter: B H P.	Weight of Water	Steam Flow Meters Hourly Readings: Boilers: 1	2	3	4
1 a.m																											
2																											
3																											
4																											
5																											
6																											
7																											
8																											
9																											
10																											
11																											
12																											
1 p.m																											
2																											
3																											
4																											
5																											
6																											
7																											
8																											
9																											
10																											
11																											
12																											

Steam Flow Meters Hourly Readings

No. 1 Unit 150 K.W D.C.: Run | Vacuum | Back Pressure | 1st Stage Pressure | Av. Amp. + | Av. Amp. −

No. 2 Unit 187 K.V.A. A.C.: Run | Vacuum | Back Pressure | Amperes 1° | Amperes 2° | Amperes 3° | Av. K.W.

No. 3 Unit 625 K.V.A. A.C.: Run | Vacuum | Back Pressure | Inlet Pressure | Hotwell | Temp. Condenser Circ. Water In | Temp. Condenser Circ. Water Out | Amperes 1° | Amperes 2° | Amperes 3° | Average K.W.

937 K.V.A.: Run | Vacuum | Back Pressure | 1st Stage Pressure

QUARTS OF OIL USED

Watch	Cylinder	Turbine	Turbo-Gear	Crank Case

OIL ON HAND (Gallons)

Watch 8 a.m.–4 p.m.	Cylinder	Turbine	Turbo-Gear	Crank Case

STEAM TO BUILDINGS

	Time On	Time Off
8" Reducing Valve		
4" Reducing Valve		
4" By-Pass Valve		
Turbine Exhaust Steam		

CITY WATER METER

	No. 1	No. 2
12:00 m.n. Reading		
Previous Reading		
Difference		

COAL USED

Watch	Pounds	K.W. Hour Reading	Rate	Water Evaporated for Watch
8 a.m.–4 p.m.				
4 p.m.–12 m.n.				
12 m.n.–8 a.m.				
Total				

Rate of Coal per K.W. Hour for 24 Hours

Water Evaporated per pound of Coal, from and at 212° F. (*From Venturi Reading*)

COAL RECEIVED

Car Numbers

Number of Cars Unloaded

Number of Cars in Bunker

Number of Cars in Yard

Names of Men Operating Coal Machinery

TIME COAL MACHINERY RUN

Time Started	Time Stopped	Hours

BOILERS BLOWN DOWN

No. at

No. at

No. at

No. at

FIRES CLEANED

No. at

No. at

No. at

No. at

No. at

No. at

No. at

Lbs. of Ashes

VOLTAGE REGULATORS

	Time Started	Time Stopped
A.C.		
D.C.		

STORAGE BATTERY

Time Started	
Charging	Discharging

A. C. BUS BARS

No. 1	No. 2
Time In	Time Out

ASH HOPPERS CLEANED

No. at

No. at

No. at

No. at

No. at

No. at

No. at

No. at

INSPECTION BY CHIEF

Boilers
Boiler Feed Pumps
Chain Drives
Condensers
Crane
Fire Pumps
Gauges
Generators
Governors
Motors
Piping
Safety Valves
Stokers
Stoker Shafting
Storage Battery
Switch Board
Toilet, Engineers'
Toilet, Firemen's
Tunnel
Turbine Fans

KILOWATT HOURS

MACHINE	Motor Generator No. 1	Motor Generator No. 2	Curtis No. 1	Station Meter	West. Turbine Exciter	West. Turbine No. 2	W
12:00 m.n. Reading							
Previous Reading							
Difference							

FIG. 15. FACSIMILE OF THE DAILY REPORT SHEET USED IN

have nonreturn valves (Edwards). Two stoker engines, each of 15 hp., are installed, one engine driving all the stokers. The three draft fans (Sturtevant) are turbine-driven, each having 15,000 cu.ft. per min. capacity. Permanent soot blowers (Vulcan) are used.

The two feed pumps (Jeansville), each of 500 gal. per min. against 175 lb., also are turbine (Terry) driven. A 4000-hp. direct-contact heater (National) heats the boiler feed, all of which passes through a venturi tube. The heater is located to give 25 lb. suction pressure on the feed pumps. A vacuum ash conveyor is installed, and a single chain-bucket conveyor elevates coal to the 66,000-cu.ft. coal bunker above the boilers.

A 20-in. exhaust main and a 10-in. live-steam main are led to the institute buildings through a concrete tunnel, the exhaust steam for heating, the 10-in. line for mechanical laboratory and heating purposes. All condensate is pumped directly back to the heater through a

JSETTS INSTITUTE OF TECHNOLOGY

POWER PLANT LOG

DATE..... 19.....

No. 4 Unit A. C.						Motor Generators						Steam Exciter 35 K.W.				Motor Exciter 35 K.W.				Motor Exciter 5 K.W.				D. C. Feeder Readings						Station Light and Power	Educational Power Reading A. C.				Electrical Engineering Feeders A. C.				Light No. 1				Secondary Lighting Mains			Night Lights A.C.				Power Transformer			
Heisett	Temp. Condenser Cir. Water		Amperes			Average K. W.	No. 1			No. 2			Run	Back Pressure	Volts	Amperes	Run	Volts	Amperes	Run	Volts	Amperes	No. 1		No. 2		No. 3																								
	In	Out	1°	2°	3°		Run	Amps. +	Amps. −	Run	Amps. +	Amps. −											+	−	+	−	+	−	Amps.	1 Am.	2 Am.	3 Am.	K.W.	1 Am.	2 Am.	3 Am.	K.W.	1 Am.	2 Am.	3 Am.	K.W.	1 V.	2 V	3 V.	1 Am.	2 Am.	3 Am.	K.W.	1 Am.	2 Am.	3 Am.	K.W.

NGINEER

FIRE CALLS

CITY FIRE DEPARTMENT

Mass. Ave. Side	Kendall Square Side
Building No.	Building No.
Floor No.	Floor No.

Time Alarm Came in

Time Alarm Given C. F. D.

Time C. F. D. Arrived

Time Fire Out

M. I. T. FIRE DEPARTMENT

Time Alarm Came in

Building No. Floor No.

No. 1 Terry Pump

Time Started Time Stopped

No. 2 Terry Pump

Time Started Time Stopped

City Water	River Water	Cistern Water
Time On	Time On	Time On
Time Off	Time Off	Time Off

%

	No. 1 Turbine Tripped
Curtis No. 4	Steam Exciter Tripped
	No. 2 Turbine Tripped
	No. 3 Turbine Tripped
	No. 4 Turbine Tripped

Repairs and Upkeep Work Done During 24 Hours

REMARKS Under this Heading Make Note of any Test Runs and Unusual Occurrences of any Kind

Chief Engineer.....

THE POWER PLANT, MASSACHUSETTS INSTITUTE OF TECHNOLOGY

5-in. line. The Warren Webster system of heating is used, and despite the great distance between the power house and the institute buildings and the area covered by the latter, no more than 5 lb. initial pressure has so far been needed on the heating system.

There are two main turbines, one a 937-kv.-a. 3600-r.p.m. extraction type, the other a 625-kv.-a. 3600-r.p.m. straight high-pressure Westinghouse. The current is three phase, 2300 volts. Two other smaller machines are provided. One exciter is motor-driven, the other turbine-driven. All these are shown in Fig. 14. The daily report sheet is shown in Fig. 15. The Stone and Webster Construction Co. built the power plant.

To Make Coated Paper for Metallic Pencil Points for indicators, recording gages, etc., use a paper of good quality and apply a thin coating of a mixture of zinc oxide 1 part, water 4 parts, gum arabic $\frac{1}{5}$ part (all by weight); mix, apply with a brush and let it dry thoroughly. Use a brass pencil point.

The Installation of Motors—III

By R. Thistlewhite

SYNOPSIS—A 10-hp. direct-current motor is taken as a working example, and all the details are worked out so as to install the machine to meet the requirements of the Board of Fire Underwriters.

All the information necessary to obtain the sizes of the material required for the installation of a given motor can be found on the nameplate. Let it be assumed that a machine is to be installed that bears the following information: Manufacturer's name, serial number, type number or letter, 10 hp., 220 volts, 40 amp., 1200 r.p.m. The motor is to be installed with exposed conduit, and is located from 35 to 45 ft. from the source of supply.

TABLE 1. THE ALLOWABLE CARRYING CAPACITIES OF COPPER CONDUCTORS

Wire Size, B. & S. Gage	Dia. Solid Wire, Circ. Mils	Area, Circ. Mils	Rubber-Covered Wires, Amp.	Wires Not Rubber-Covered, Amp.
18	40.3	1,624	3	5
16	50.8	2,583	6	10
14	64.1	4,107	15	20
12	80.8	6,530	20	25
10	101.9	10,380	25	30
8	128.5	16,510	35	50
6	162.0	26,250	50	70
5	181.9	33,100	55	80
4	204.3	41,740	70	90
3	229.4	52,630	80	100
2	257.6	66,370	90	125
1	289.3	83,690	100	150
0	325.0	105,500	125	200
00	364.8	133,100	150	225
000	409.6	167,800	175	275
	447.2	200,000	200	300
0000	460.0	211,600	225	325
		300,000	275	400
		400,000	325	500
		500,000	400	600
		600,000	450	680
		700,000	500	760
		800,000	550	840
		900,000	600	920
		1,000,000	650	1,000

TABLE 2. SIZE OF CONDUITS FOR THE INSTALLATION WIRES AND CABLES

Wire Size, B. & S. Gage	One Conductor in a Conduit. Conduit Size, In.	Two Conductors in a Conduit. Conduit Size, In.	Three Conductors in a Conduit. Conduit Size, In.	Four Conductors in a Conduit. Conduit Size, In.
14	½	½	½	¾
12	½	½	¾	¾
10	½	¾	¾	1
8	½	1	1	1
6	½	1	1¼	1¼
5	¾	1¼	1¼	1¼
4	¾	1¼	1¼	1½
3	¾	1¼	1¼	1½
2	¾	1¼	1½	1½
1	¾	1½	1½	2
0	1	1½	2	2
00	1	2	2	2½
000	1	2	2	2½
0000	1¼	2	2½	2½
200,000	1¼	2	2½	2½
250,000	1¼	2½	2½	3
300,000	1¼	2½	2½	3
400,000	1¼	3	3	3½
500,000	1½	3	3	3½
600,000	1½	3	3½	..
700,000	2	3½	3½	..
800,000	2	3½	4	..
900,000	2	3½	4	..
1,000,000	2	4	4	..

The insurance companies require that the wires supplying a direct-current motor shall be made large enough to carry 25 per cent. overload, consequently if the full load of a 220-volt, 10-hp. motor is 40 amp., 125 per cent. of this will equal 50 amp. Referring to Table I under the heading, "Rubber-Covered Wires," a No. 6 B. & S. gage will be found to be the correct size. This wire will have to be a double-braid rubber-covered conductor, or type R. D., because the code calls for all wires of No. 6 or larger to be of this type. The size of conduit which will allow these two wires to be drawn in without danger of injuring the insulation can be taken from Table II under the heading "Two Conductors in a Conduit," and will be found to be 1 in. Whether the conduit is black or galvanized does not matter, the black being the cheaper, but requiring a little more work to install.

Switches and cutouts are made in 30-, 60- and 100-amp. sizes and up, so a 60-amp. size switch and cutout will have to be installed for the motor in question, this being the nearest larger size to the current to be carried. The size of fuse will be somewhere between one sufficiently large to carry the motor current and one that would not exceed the carrying capacity of the wire supplying the motor and may be chosen as from 40 to 45 amp.

It is assumed that the feeders supplying the power in the building are installed in conduit and the wiring for the motor started at the nearest switch box on the feeder circuit and that this box is of the sheet-iron type having knockout holes for the entrance of the conduits.

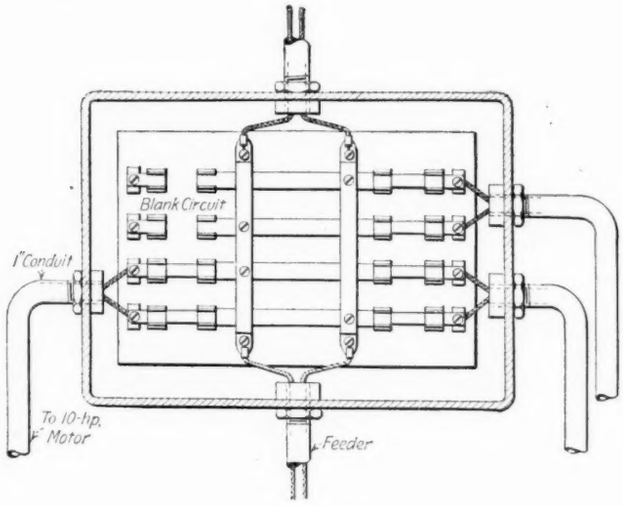


FIG. 1. FOUR-CIRCUIT PANEL BOX

It is further assumed that the box contains four circuits, two of which are not in use as shown in Fig. 1. In boxes of this type the conduit must enter exactly opposite the terminals to which the wires are to be connected, as there is no provision made for running loose wires inside the box.

The conduit is inserted into the hole provided and secured in place by a locknut on the outside and a bushing on the inside in such a manner that they will make good electrical contact between the box and pipe; scraping off the enamel with which they are coated to attain this result. Conduits are bought in 10-ft lengths, threaded at each end and provided with one coupling per length. Before the pipes are coupled together, the threads on the ends must be run over with a die, particularly on black pipe, so that all the enamel is cleaned out from between them. If the pipe has been cut, the inside of it must be reamed out sufficiently to take off the sharp edges left after cutting. The conduits should be coupled together so that the ends just touch each other—not too

tight, or the inside edges will turn in and partly close up the pipe, which would prevent the wires from being drawn in, or at least damage the insulation if they are forced. Fig 2 shows a section of two pipes correctly coupled.

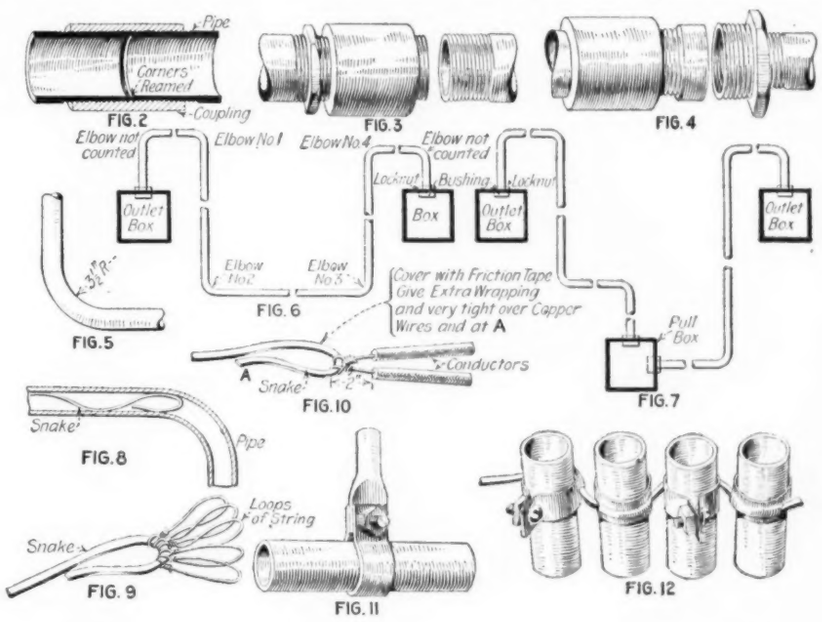
Where conditions are such that neither the length of pipe already in place nor the length which is to be coupled to it can be turned, the connection will have to be made by turning the coupling over a running thread cut on one of the pipes; the other pipe will only require a thread of standard length. The running thread is cut about ⅜ in. longer than the coupling, a locknut is then screwed on the running thread and after this the coupling until flush with the end of the pipe, as shown in Fig. 3. The pipe to be connected is now held up in place and the coupling screwed back until the ends of the pipes are in the center of it; after which the locknut is screwed up against the coupling to prevent the latter from working back.

Joining two pipes under these foregoing conditions can be done by special fittings, one being a coupling with a right-hand thread on one end and a left-hand thread on the other. This means that the pipes to be coupled will also have to have right- and left-hand threads cut on their ends. This is not at all desirable, as two different dies will be required and it also increases the chances of error. A second special fitting, which can be used to overcome this difficulty, is the Erickson coupling, shown in Fig. 4. This coupling is similar to a pipe union except that it has no washer to make it water- or steam-tight when in place. It has the advantage that no longer threads than the standard need be cut. The conduit should be installed as nearly as possible in a straight line connecting the motor with the supply. When exposed, turns should be made at right angles and not cut across diagonally, or the work will look very unsightly when finished. Right-angle bends must be made with as large a radius as possible—under no circumstance less than 3.5 in., measured from the inside edge of the bend, Fig. 5. The completed run must not contain more than four of these right-angle bends—that is, four bends in between any two boxes—except where these bends are very close to the boxes, which need not be counted when limiting the number to four. If there are no right-angle bends but a number of offsets, these must be limited to what would be equivalent to four right-angle bends. Just how many this would be will depend on their length and how much they are bent from the straight run.

Considering two points that have to be connected with conduit requiring a greater number of bends than four, due to the shape of the building, when the limit has been reached one of the bends can be replaced by a box, which must be accessible, contain no splices and be provided with a blank cover. Under these conditions the box would be known as a pullbox, and as many as necessary can be installed to prevent more than four bends between boxes. The wires, when drawn in, are pulled from box to box. Fig. 6 shows a line of conduit containing the minimum number of bends without using a pullbox, and Fig. 7 shows a line containing more than the limit, but with a pullbox replacing one bend.

At the motor end of the run a main switchbox will terminate the conduit, which must be large enough to hold the switch with the door closed when the switch blades are opened to their full extent. The switch must be placed as close to the motor as convenient and the conduit fastened to the switch box with a locknut and bushing in a manner that will make a good electrical connection.

When a conduit run contains a number of bends or offsets, difficulty may be experienced in snaking the pipe, usually caused by some bend remote from the end where the snake enters. A considerable length of snake will be lying in the pipe when the end is pushed against the bend and if pushed hard, it will bend and form a sort of spring inside the pipe (Fig. 8). Under these conditions it will sometimes be impossible to push the snake



FIGS. 2 TO 12. PROPER INSTALLATION OF CONDUIT AND CONDUCTORS

around the bend, and rather than waste time trying, it is better to withdraw it and try entering the snake from the other end of the conduit. Sometimes, however, if too much pressure is not put on the snake, it can be gradually worked around the bend. If the same difficulty is encountered from the other end of the pipe, then two snakes will have to be used, one from each end. On the end of one of these attach some loops of cord, as in Fig. 9, and then push the two snakes toward each other until they meet inside the pipe, and gradually withdraw them, repeating this until the snakes are finally hooked together. Once they are hooked together, hold them tight and carefully draw the longest snake through. This is best done by pushing the longer snake into the pipe and at the same time pulling on the shorter one.

The wires are now attached to the loop on the end of the snake by hooking one into the other, as in Fig. 10, and covering them with a layer of friction tape. The drawing in will have to be done by two men, one at each end of the line. One man will feed the wires

in as straight as possible and at the same time push them through, while the other pulls on the snake at the same instant that the push is made. This is very important if the work is to be done with ease. For instance, it would require three or four men to pull the wires through if they were all pulling at one end and no one pushing at the other, with a great risk of injuring the insulation on the wires. In hard pulls, never use greasy materials as a lubricant; if any is found necessary, a little powdered soapstone is the best. For large wires the snake is used to draw in a rope which in turn is used to pull in the wires.

The installation between the main switch and the motor can, with the use of suitable pipe fittings, be run without

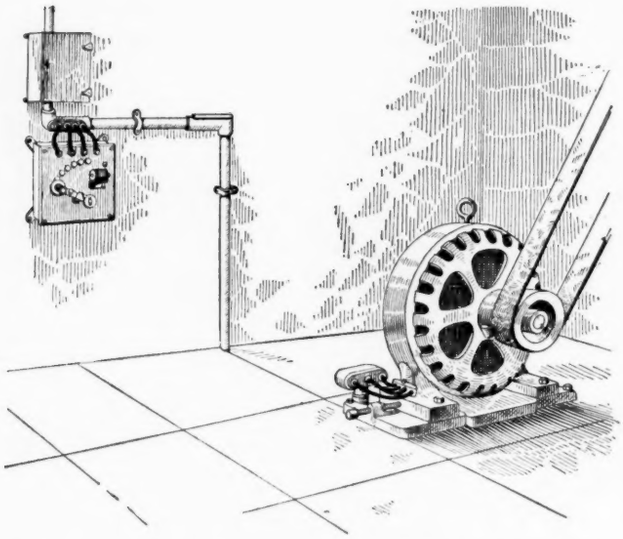


FIG. 13. METHOD OF RUNNING CONDUIT AND WIRES FROM STARTING BOX AND SWITCH TO MOTOR

any exposed wires except right at the starting box and motor terminals. Fig. 13 shows an installation that is run in this manner.

A 1-in. pipe will be large enough to take care of the three wires running between the starter and the motor, which will consist of two No. 6 double-braid conductors for the armature and line connections and one No. 12 single-braid wire for the shunt-field connection. The code does not require single wires of a smaller size than No. 6 B. & S. to be double-braided.

The grounding of the system can now be done, and need be connected at only one point if all the parts are properly bonded together. Therefore from any point on the conduit run which is nearest to a steam or water pipe, connection can be made by means of a ground clamp. These clamps are made adjustable in a type for connecting a wire at right angles to the pipe, Fig. 11, and large enough to take a No. 10 or a No. 6 ground wire. When the circuit wires are No. 0 or less in size, the ground wire will have to be at least No. 10, and a No. 6 will have to be used when larger wires than No. 0 are installed. In the case under consideration a No. 10 will be large enough, but as the wire being run is only a No. 6, a piece of this same wire can be used to advantage, if the distance from the conduit to the ground pipe is short, although if this distance is considerable, it would be cheaper to use the No. 10 wire. The ground wire can be run in conduit or any other method so long as it is put up in a mechanical manner.

Where a number of pipes enter the same box, as at the feeder-supply box, they should all be connected together. This can be done in the best mechanical manner by using the ground or bonding clamp shown in Fig. 12. The bonding is required so that the ground wire will earth all branches without running a ground wire for each branch.

The conductors can now be connected to the cutout at the feeder end of the run and also to the terminals of the motor switch, and the fuses inserted, which will bring the power close to the motor for testing. This can be done by placing a test lamp in series with the line, the various terminals on the motor being located by the effect on the light. When the test leads are placed across the shunt-field terminals, the light will appear dim and when across the armature terminals bright. The terminals on the starting box will be found marked $L+$, $L-$, A, and F. The connections between the box and the motor are made according to Fig. 14.

Before starting the motor, oil the bearings, examine the brushes for correct position (which is usually marked on the rocker arm and the frame of the machine) and for proper bedding of the brushes to the commutator; the motor is then ready for the first tryout, which should be without load. The motor should start when the starting-box arm is placed on the first notch, or at least on the second. If everything is correct, the machine may be given a trial run with its load. The starting arm may have to be moved over to the second notch in order to start the load, but no farther than this. For heavy loads—that is, loads that are hard to get up to full speed—the starting box should be of the 30-sec. rating; that is,

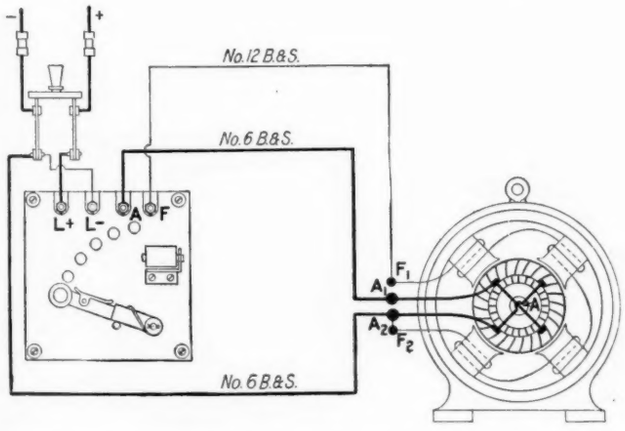


FIG. 14. CONNECTION DIAGRAM OF A SHUNT MOTOR TO A FOUR-TERMINAL STARTING BOX

the box must not be in circuit more than 30 sec. For loads that are run up to full speed easily, a 15-sec. box would be large enough. Keep a close watch on the no-voltage release coil for a little while on the first run, as this coil may heat up owing to the field taking more current than the wire on the coil will carry.

The work is now ready for the inspector, to whom, before the installation is begun, an application should be sent stating when the work will be commenced and when it will be completed, also when he is required to call. Where the inspector does not inspect a portion of his district except at stated periods, the central station will usually look the work over and give permission to run during the interim if outside power is used.

Equivalent Cost of Coal and Oil as Fuel*

By R. L. Wales†

SYNOPSIS—Besides showing a chart to assist in quickly determining the equivalent cost of coal and oil fuel, the author considers some of the advantages of oil.

In the present day of high prices of all grades of coal, the power-plant manager naturally turns to the possibilities offered by fuel oil in his efforts to keep down the cost of operation. The problem of substituting fuel oil for coal is no longer one of engineering difficulties, but rather one of relative expense, all phases of the power problem being considered. If it were true that equal costs per million B.t.u. from coal and from oil meant equal operating costs, the problem would indeed be simple. A brief calculation involving heating values and costs per pound would settle the whole question. The difficulty of the problem arises from the fact that, owing to incidental economies peculiar to the use of oil fuel, a million B.t.u. from the latter is equivalent to considerably more than a million B.t.u. from coal in the matter of power generation. In other words, it will usually be true that a considerably higher price may be paid per million B.t.u. for heat from oil than from coal, still keeping the total cost of power production the same.

Some of the specific offsets to higher cost of oil fuel per B.t.u. are as follows: (a) Increased efficiency of furnace and boiler; (b) reduced expense of boiler-room labor; (c) elimination of cost of ash removal; (d) facility of handling and storing; (e) smaller expense for upkeep; (f) more perfect control; (g) increased capacity; (h) usually less smoke. The actual monetary significance of these advantages will vary widely with the character and location of the plant.

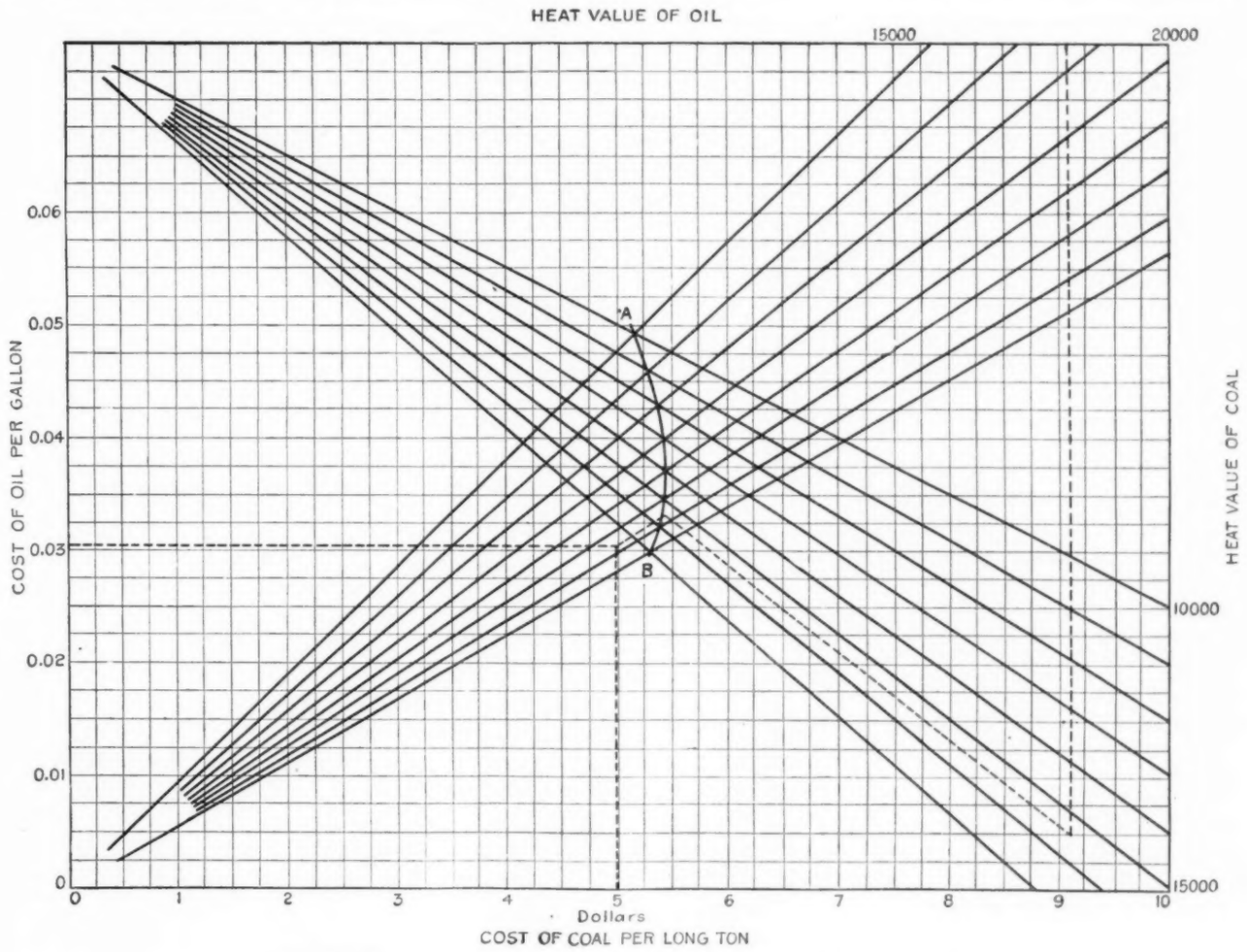


CHART TO DETERMINE RELATIVE COST OF COAL AND OIL FUEL

Regarding efficiency of furnace and boiler, it is to be noted that since it is possible to burn oil completely with very much less excess of air than is necessary with coal, the weight of chimney gas per thousand B.t.u. developed is smaller than with coal. This means a higher furnace temperature, more effective action of the heating surfaces and a smaller percentage loss to the stack. Gains from this source and from freedom from the loss of fuel through grates, etc., amount to appreciable saving under test conditions. If the advantages of restricting the air supply are to be made the most of,

*See also "Oil Fuel in New England," "Power," Dec. 19, 1916.

†Dean, department of engineering, Rhode Island State College, Kingston, R. I.

long and deep furnaces, allowing ample combustion space, are necessary. Since very little draft is required to burn oil, tall stacks, designed for the combustion of coal, will tend to draw an unnecessary excess of air through the furnace and thereby reduce the possible economy, unless adequate control be established through an analysis of the chimney gases. Approximately 12 or 13 per cent. CO_2 in the flue gas corresponds to the condition of maximum efficiency. Smaller gains in economy are to be expected in plants where economizers are used, since with oil fuel, the weight of chimney gas, and hence the quantity of heat available to the economizer, is less than with coal.

Owing to the perfection of control with fuel oil, the possibility of adjusting furnace conditions more exactly to the requirements of the load, through peaks and through periods of "banked fires," the gains due to the use of oil may be considerably greater than indicated by the percentages mentioned.

Oil's Greater B.t.u. Value

The results of comparative tests of coal and oil on a small coasting steamer showed that for the given conditions 91 B.t.u. from oil gave the same effect as 100 B.t.u. from coal. The steamship "Nevadan" covered the distance between New York and San Diego on 2269 tons of coal. In traveling over the same course and using oil as a fuel, 9126 bbl. was consumed. This indicates 79 B.t.u. from oil as the equivalent of 100 from coal. Service tests of six months each on oil and coal, carried out on eleven of the Southern Pacific Co.'s bay steamers, showed about 75.5 B.t.u. from oil equivalent to 100 from coal. Similar tests on locomotives gave a ratio of 87.5 to 100. These tests would indicate that on the average about 84 B.t.u. from oil are the equivalent of 100 B.t.u. from coal in so far as service evaporation is concerned.

The use of oil fuel allows the labor bill for boiler attendance to be cut to about one-third that when coal is used. The substitution of oil for coal on the steamship "Nevadan" resulted in cutting the stokeroom crew from fifteen to six. A stationary plant operating four 500-hp. boilers reduced the fireroom force from four to one by a similar substitution. On the average for large plants the cost of boiler-room labor may be taken as 7.5 per cent. of the operating costs. It may be assumed, then, that with oil firing, boiler-room labor will be reduced to 2.5 per cent. of operating costs. Of course it must be borne in mind that in small plants requiring only one or two men in the boiler room, this reduction would not be possible.

Coal and Ash Handling Saving

The elimination of the cost of handling and removing ash will effect a further saving of about 3 per cent. of operating expense on the coal basis. The actual money value of the other advantages of oil fuel are so dependent on local conditions that no general estimate can be made.

Keeping the foregoing in mind, together with the fact that in coal-operated plants the cost of fuel amounts to from 40 to 70 per cent. of operating costs, we may estimate the excess price which may be paid for heat from oil over that from coal. For this purpose it is assumed that the average of the above figures, or 55 per cent., represents the fuel cost in the coal-operated plant. The items that will be considered as controlling are evaporative efficiency, boiler-room labor and the expense of ash removal.

In the coal-operated plant the following items of expense will occur for every $100 spent in operating: Fuel, $55; boiler-room labor, $7.50; ash handling and removing, $3; total, $65.50.

In the oil-operated plant 84 B.t.u. will do the work of 100 B.t.u. from coal. Consequently, at the same cost per B.t.u. the fuel expense will be only $0.84 \times \$55 = \$46.20$. The labor bill will be reduced to one-third its previous value, or to $2.50. The item involving ash will not appear. Hence, for the oil-operated plant we shall have: Fuel, $46.20; boiler-room labor, $2.50; ash, $0.00; total, $48.70.

This indicates that at the same price per B.t.u. for oil as for coal, $16.80 could be saved in every $100 of operating expense by substituting oil for coal. Evidently, then, the cost of oil could be increased by this amount without making the total cost greater than with coal; or the maximum amount which should be paid for oil out of every $100 of operating expense is $46.20 plus $16.80, or $63. The figure $46.20 assumed the same price per B.t.u. as for coal. The maximum allowable cost for oil fuel, then, would be $63.00 ÷ $46.20, or 136 per cent. that per B.t.u. for coal.

On the basis of the foregoing it would appear that oil fuel will result in operating economy up to a price per B.t.u. 36 per cent. in excess of that for coal.

As a ready means of determining the cost per gallon of oil fuel which will make the cost of operating the same as with coal at various prices per long ton, the chart here shown, has been prepared. The method of using this chart will be evident from the following example, the solution of which is indicated in the dotted lines on the diagram.

Use of the Chart

Example: Find what cost of fuel oil in cents per gallon will make the cost of power equal to that with coal at $5 per long ton. The heating value of the oil is taken as 18,200 B.t.u. per lb.; that of the coal as 14,000 B.t.u. per lb.

Method: Drop vertically from heating value 18,200 at the top of the chart to intersection with the horizontal from heating value 14,000 at the right. Follow oblique line from this intersection, upward toward the left-hand corner of the sheet until curve *AB* is reached. From the intersection with *AB*, follow the oblique line toward the lower left-hand corner of the page, to the intersection with vertical from the price of coal, $5, at the bottom. From this point pass horizontally to the left, intersecting the ordinate of oil prices at $0.0305 per gal.

The chart is constructed on the assumption that 36 per cent. more can be paid for B.t.u. from oil than from coal, in accordance with the results of the foregoing data. While this figure will be suitable under average conditions, in certain cases it may well happen that, owing to peculiarities of the plant or to unusual and predominating importance of some advantage such as cleanliness, nicety of control, etc., this figure should be modified. For example, one operator finds that 50 per cent. more can be paid for oil than for coal. In this case the results from the chart should be multiplied by the ratio of the substituted percentage to 36. This would give as a result to the problem, $0.0305 \times {}^{50}/_{36} = 0.0424$.

Unpacking and Repacking the Ammonia Pump

By H. G. Gibson

Packing the ammonia stuffing-box on the pump is a job that the absorption-plant operator must do at more or less regular intervals. Like other disagreeable jobs, there is a way to do it that reduces the unpleasantness to a minimum.

The layout that will be used as an illustration is planned as shown in Fig. 1. It will be assumed that the plant has been shut down for a few hours and that packing the pump is the next thing in order. Valves 1, 4 and 5 are opened and the liquor is pumped out of the absorber, after which the pressure in the absorber should be at or near zero. Valve No. 1 is then closed, and if the liquor in the machine is not already too "weak"—that is, if the percentage of ammonia is not less than it should be—a couple of bucketfuls of distilled water is put into the funnel (shown just above valve No. 2) and forced into the generator by the pump. Valves 4 and 5 should then be closed and No. 3 opened, and either by hose connection or bucket, tap water should be fed into the funnel and the pump allowed to force it through valve No. 3 into another bucket or, better still, a connection to the sewer. This should be continued until the pump chambers are thoroughly flushed out. Then, without shutting off the water and with the pump

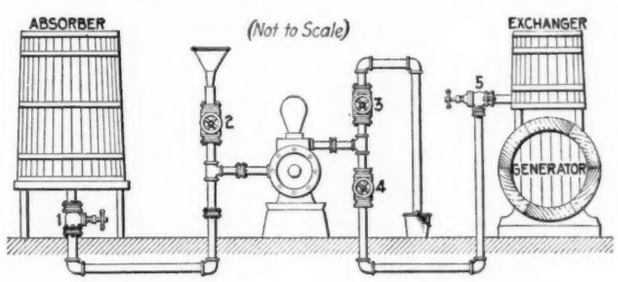


FIG. 1. LAYOUT FOR ABSORPTION SYSTEM

still running slowly, the stuffing-box gland should be eased off. If the pump is allowed to run slowly, the gland may be entirely unscrewed and the water will force out all the old packing without injury to the gland or spool. This is a much easier, cleaner, quicker and less odoriferous method than when the packing is pulled out of the box dry with a packing hook.

Having now unpacked the pump, proceed to repack it. Consider Fig. 2. The stuffing-box (this particular one) is long enough to hold about 12 rings of packing; 9 of them are put in ahead of the spool and 3 behind it. There is an enlargement in the lower side of the stuffing-box and into this section two plugs, *A* and *B*, are screwed. Running lengthwise in this enlarged section is a port which is a continuation of the cavity filled by plug *A*; this port empties into the suction-valve chamber. The cavity filled by plug *B* is continued as a port up through the lower wall of the stuffing-box. The spool *S* is shown separately in Fig. 2. The view given is that of the bottom of the spool as it lies in working position in the box. There is a port, not shown, almost the full length of the spool; on the crosshead end there are two ⅜-in. holes tapped an inch or so deep.

With the box clean and the spool and plug *B* removed, insert the first ring and push it in as far as possible with the fingers, then farther with the spool. Now take a ⅜-in. bolt about 12 in. long and screw it into the spool a couple of threads. With the bolt for a handle, use the spool for a ram and force the ring back hard against the bottom of the box. Follow this ring with another, staggering the joints in the packing. Continue this until the end of the long port in the bottom of the spool just overlaps the port extending up from plug *B*. This is determined by running a small bolt or pencil up into the port. When this condition obtains, there is enough packing behind the spool, and leaving it in this position, enough rings are put in after it to fill up the box. Replacing the gland and plug *B* and closing valves Nos. 2 and 3 completes the job.

The reason for the ports extending from plugs *A* and *B* are thus explained: Any ammonia liquor that finds its way through the packing to the spool is returned to the suction valve chamber through these ports. Taking up on the gland forces the spool farther into

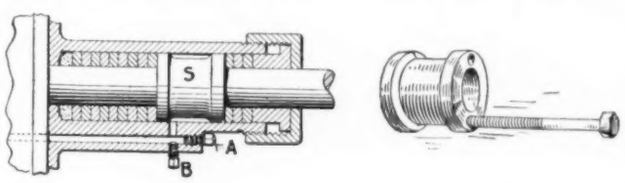


FIG. 2. TAPPED HOLE IN LANTERN TO FACILITATE REMOVAL

the box, but the shape of the spool allows the liquor to find its way to the return ports no matter what its lengthwise position in the box. It is well when repacking the pump to remove plug *A* also and see that the longitudinal port is clear all the way. Bits of packing are apt to lodge there and obstruct the flow.

It might be well to tell at this time of the disagreeable experience of an engineer who started a plant of this kind shortly after the pump had been repacked. He knew that the pump had been worked on and thought that everything was all right for starting. He proceeded to open valve No. 1 and had only got it started when a stream of ammonia liquor gushed from the funnel and came down on his head and back. Fortunately, his face was turned away from the funnel. There were other men working in the next room and they helped him to the water tap and showered his head with water. Investigation showed that valve No. 3 had not been closed when the job of repacking the pump was completed. The high pressure in the generator had forced some liquor over into the absorber through imperfectly seated valves in the weak-liquor line. Some pressure had thus been built up in the absorber, and when he opened valve No. 1, there was nothing to prevent the ammonia spurting out of the funnel. Luckily, he suffered no serious injury, but the experience taught him, and also those who were responsible for the accident, to be more careful in the future.

Expansion in a Steam Line may be found by the rule, $E = \frac{(L \times 12) \times (T - t)}{150{,}000}$, where E = the expansion in inches, L = the length of the line in feet, which is multiplied by 12 to reduce to inches or (L × 12), T = the temperature of the pipe when heated, t = the original temperature of the pipe, and 150,000 is a constant.

Steam-Engine Troubles—Wristplates

By H. Hamkens

SYNOPSIS—Eleventh of a series treating of the good and bad features of design found in Corliss engines. For warming up, starting, stopping and occasionally reversing an engine, nothing simpler than the single wristplate has been devised. Parallel-motion valve gear is best for high speeds.

The single wristplate has been a favorite for years. It seems hard to break away from it, with its toggle motion, ease of adjustment and handling. For warming up, starting, stopping and occasionally reversing an engine, nothing simpler has ever been devised. There is a variety of wristplates in existence—old pear-shaped affairs with long throw, significantly called swingplates by their makers; wheel wristplates; round, balanced and spider wristplates—all of which are subject to the same defect, inertia. Some of them are heavy, throwing considerable strain on hook and eccentric rods. Fig. 152 shows the different kinds of wristplates mentioned.

Although the single type, limiting the cutoff in the cylinder to about $\frac{7}{16}$ of the stroke was partly responsible for the remarkable economy of the old Corliss engines, compared with late-cutoff slide-valve engines, on account of the more rational expansion which users of these engines were compelled to adopt, the tendency is to eliminate it and substitute a valve motion which will permit of a long-range cutoff for occasional extremely heavy loads and which is also suitable for higher rotative speeds. This is done in several different ways—by using two wristplates, or one wristplate for the exhaust and parallel motion for the steam, or parallel motion for both steam and exhaust

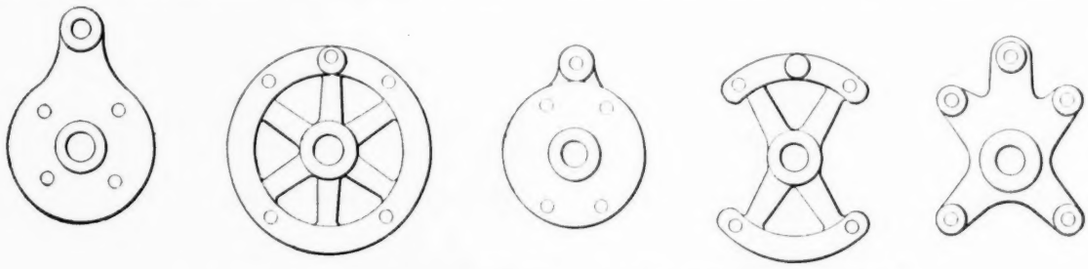


FIG. 152. COMMON FORMS OF WRISTPLATES FOUND IN PRACTICE

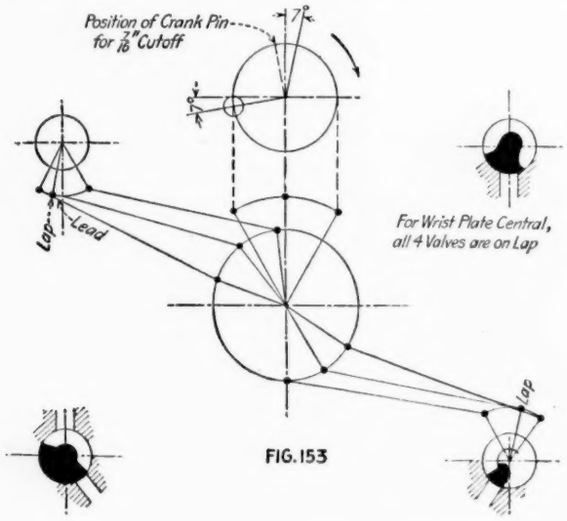


FIG. 153

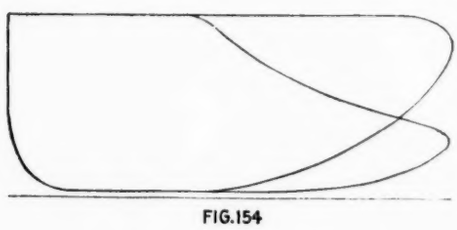
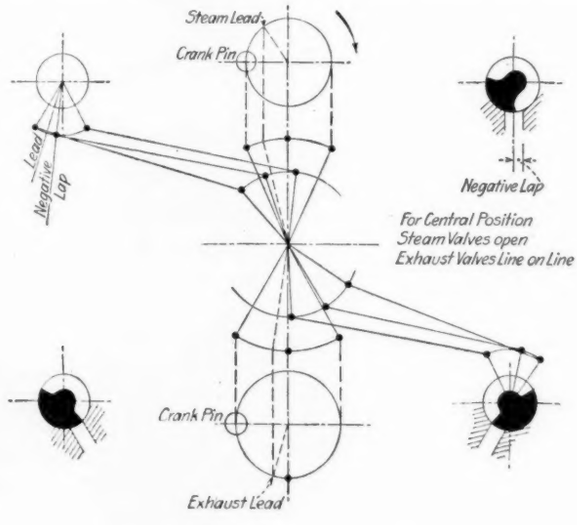


FIG. 154



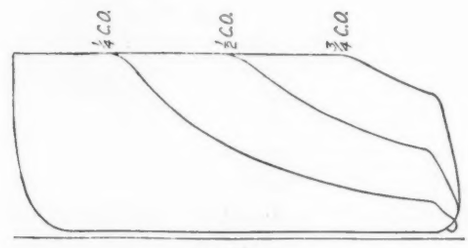


FIG. 155

FIGS. 153 TO 155. SINGLE AND DOUBLE ECCENTRIC WRISTPLATE MOTION DIAGRAMS

The objections to wristplates, of course, are greater inertia, more wear, lubrication and repairs. The parallel-motion gear seems to be the only feasible one. It is a trifle more complicated.

On the single-eccentric wristplate motion shown in Fig. 153 any valve can be adjusted independently of the others, for lap with the wristplate central and for lead with the crank on the dead centers. A study of the valve-gear diagram shows its limitation and also the trouble that may be expected if an engine with this motion is overloaded. Single ports are shown for simplicity. The principle is the same for double or any number of ports. With the wristplate in the central position all the valves must be on the lap. Disregarding all angularities of the connecting-rod and eccentric rod, the relative positions of the crankpin and eccentric for the mid-position of the wristplate are shown in the detail. The eccentric stands for this position at 90 deg. to the horizontal and the crankpin about 7 deg. below. Moving the crankpin to the dead center advances the eccentric 7 deg. from the vertical center line; the head-end steam valve is now on the lead, and if we move the crank around until the eccentric reaches its extreme travel, we find that it has reached a position 7 deg. from the vertical center line. This represents the latest cutoff which the valve gear affords. If the valve gear has not been tripped by the time the eccentric and wristplate have reached their limit, the engine will take steam full stroke; there is no regulation possible between about $\frac{7}{16}$ cutoff and full stroke, and if an overload is put on requiring more steam than the $\frac{7}{16}$ cutoff can admit, the speed of the engine will be irregular. Not only that, but all the working parts will be strained. It takes a certain amount of time to close a steam valve when wide open, therefore an indicator card may show a cutoff of 50 per cent. for a single-eccentric gear, which, of course, is theoretically impossible if the exhaust valves have the requisite amount of lap and lead for compression and release. The steam valve at the head end works simultaneously with the exhaust valve at the crank end and *vice versa*. Therefore, the same distance through which the wristplate travels to move the steam valve from the lap to the lead position is utilized to make the exhaust valve at the other end travel from lap to lead and no more; the motion of one depends on that of the other. This explains in part why a single-eccentric valve gear is limited as to compression and release for the exhaust. The hands of the designer are tied, so to speak, on this valve gear; if he advances the eccentric to give an earlier release and more compression, he reduces the range of cutoff, and if the eccentric is moved back, release and compression will be reduced and the cutoff extended.

A late-cutoff indicator diagram is shown in Fig. 154. The effect of imperfect release is clearly noticeable. The diagram for steam full stroke in the same figure shows pronounced wire drawing in the exhaust port. No fixed rule can be established for the amount of lap and lead that should be given the valves of an engine. That depends on the throw of the wristplate and the travel of the valves, which varies with the different makes of engines. Most all Corliss engines have marks on the valves showing the cutting edges and the necessary lap; a few of them indicate the lead. As stated before, with the wristplate central the valves must be on the lap, if there are no lead marks.

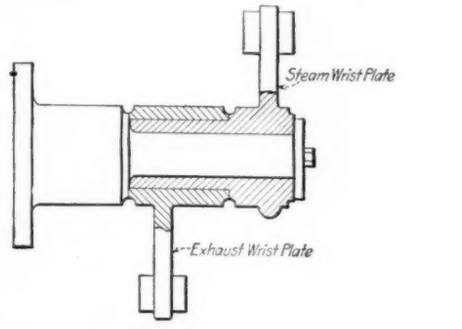


FIG. 156

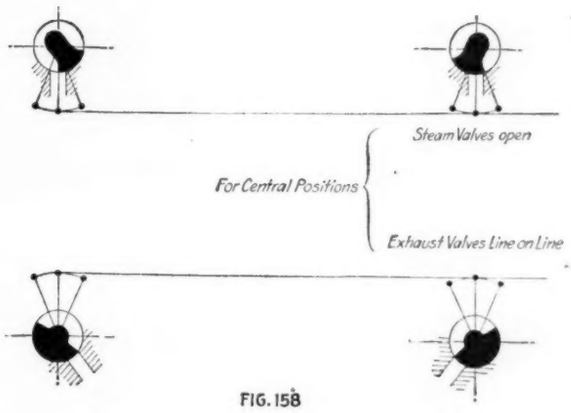


FIG. 158

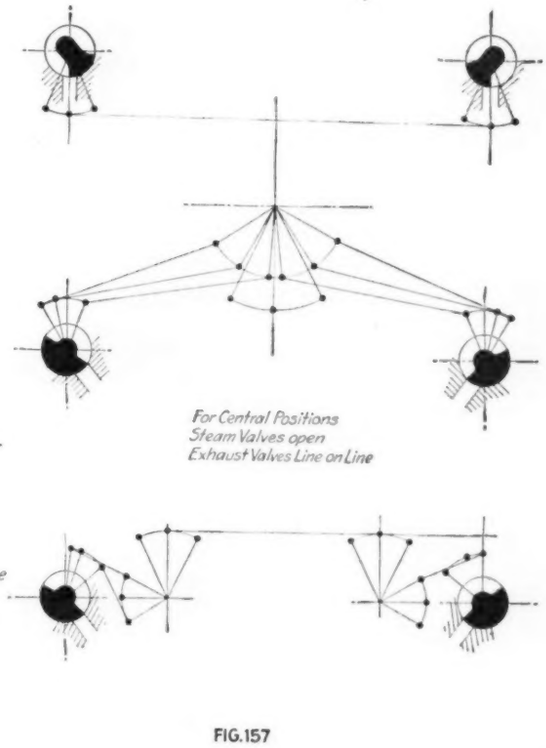


FIG. 157

FIGS. 156 TO 158. WRISTPLATE HUB AND PARALLEL-MOTION DIAGRAMS

The following table may be used for the steam valves, with the understanding that it is subject to change to suit conditions:

Size of engine, in	12	14	16	18	20	22	24	26	28
Lead of steam valve, in	$\frac{3}{32}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{16}$	$\frac{1}{16}$	$\frac{1}{4}$	$\frac{1}{4}$

An engine better have too little steam lead than too much, for the latter may cause a pound by forcing the piston ahead with a blow instead of gradually. This is especially

true for a condensing engine where the compression is low.

If an engineer could have a valve-gear diagram of his engine mounted on a board on the wall, showing the ports of the cylinder, cutting edges of valves, their lap, lead and extreme travel, also the throw of the wristplate and motion of the pins with the position of the governor rods and cams, distance between valve-rod centers, etc., it would be a help to him to keep the valve gear in good order.

The diagram shown in Fig. 155 represents a double-eccentric wristplate motion. In this the steam and exhaust valves can be set independently of each other. Release and compression can be adjusted most advantageously, as shown in the indicator diagram. For long-range cutoff both steam valves will be open or will have negative lap with the wristplate in the central position. The governor must always trip the valve gear at the end of the stroke, otherwise steam will blow through into the exhaust port when the engine is started or takes steam full stroke. The cutoff can be extended to $\frac{8}{10}$ of the stroke. It is not well to go beyond that, for live steam might go to waste through the exhaust. The steam wristplate in this valve gear is of course superfluous; it is a convenience in starting and handling the engine, but otherwise it is an unnecessary adjunct, which requires lubrication and looking after, especially if the exhaust wristplate has its bearing on the hub of the steam wristplate, as shown in Fig. 156, the way it is on many engines.

The valve-gear diagram, Fig. 157, shows parallel motion used for the steam valves and a wristplate for the exhaust. Advocates of this system claim that the wristplate motion brings the exhaust valve almost to a stop during the period of admitting steam to the cylinder; others assert that the live-steam pressure on the almost stationary valves will make them stick to their seats, and that the rapid motion in opening imposes an excessive strain on the valve-gear parts. Sometimes, instead of using the heavy wristplate, which is objectionable on high speeds, each exhaust valve is driven by a bell crank and link, shown below the wristplate motion in Fig. 157. The weight and inertia are probably reduced in this design, but the number of parts has been increased, and it does not seem to be much of an improvement.

For high speeds the parallel motion shown in Fig. 158 appeals to the exacting man. There are no unnecessary wristplates, bell cranks or links used. The motion of the exhaust levers is, like that of the rocker arm, easy and gradual; they are always moving, there are no sudden jerks or stops, and the exhaust valves are not likely to stick to their seats.

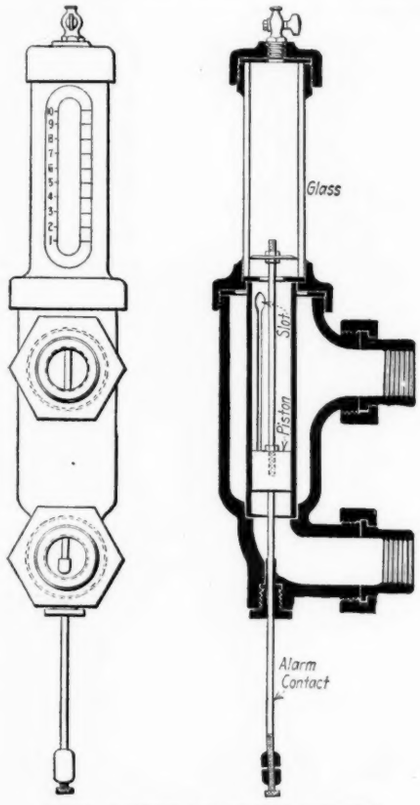
In making adjustments of the parallel-motion gear it must be borne in mind that the valves at the head end of the cylinder are affected by changes made in the setting of the valves at the crank end, at least as far as the shortening or lengthening of the parallel rods are concerned, and that they must be adjusted to their original position unless a change for them also is desired. When a change is made in the length of the steam valve and with parallel rods, the dashpot rods must be adjusted; an oversight in this direction may result in a broken bonnet or other trouble.

[*The next article, though not the last of the series, will give a summary of the good points to look for in an engine.*]

Vaughan Flow Meter

A meter designed for indicating the flow of liquids in pipes is the Vaughan, made and sold by the Spray Engineering Co., Boston, Mass. It is shown in section in the accompanying illustration. The instrument consists of a cylindrical chamber with suitable pipe connections inclosing a slotted tube through which the liquid must pass.

Inclosed in the slotted tube is a piston which, as the liquid is turned on, is carried up until the exposed area of the slots is sufficient to allow the flow of the liquid up to the capacity of the indicator. An index is attached to the upper end of the piston rod, which extends up



THE VAUGHAN FLOW METER

into a glass tube at the top of the cylindrical chamber. The glass tube is in a protecting cover, corresponding to the movement of the piston, to be noted. A scale on the side of the case enables the determination of the amount of flow in gallons per minute.

An electric contact consisting of an adjustable brass rod set through an insulated stuffing-box at the bottom of the chamber can be connected to a lamp or bell, calling attention when the flow has fallen below a fixed minimum. Contact is established where the piston rests on the brass rod. The flow is directly proportional to the area of the slots in the inclosed tube, or to the rise or fall of the piston.

Under test the indicator gives practically straight-line calibration over a large range, and the loss of head in operating the instrument has been found to be negligible, not exceeding 0.004 lb. per sq.in. with a capacity of 15 gal. per min.

Pressure on Bearings—Slow-speed alternate: Crank-pins, 1,000 to 3,000; crosshead, 1,000 to 1,200; main bearings, 800 to 900; guides, etc., 25 to 60; lineshaft, 10 to 30 lb. per sq.in.

The Electrical Study Course—Elements of Electricity—III

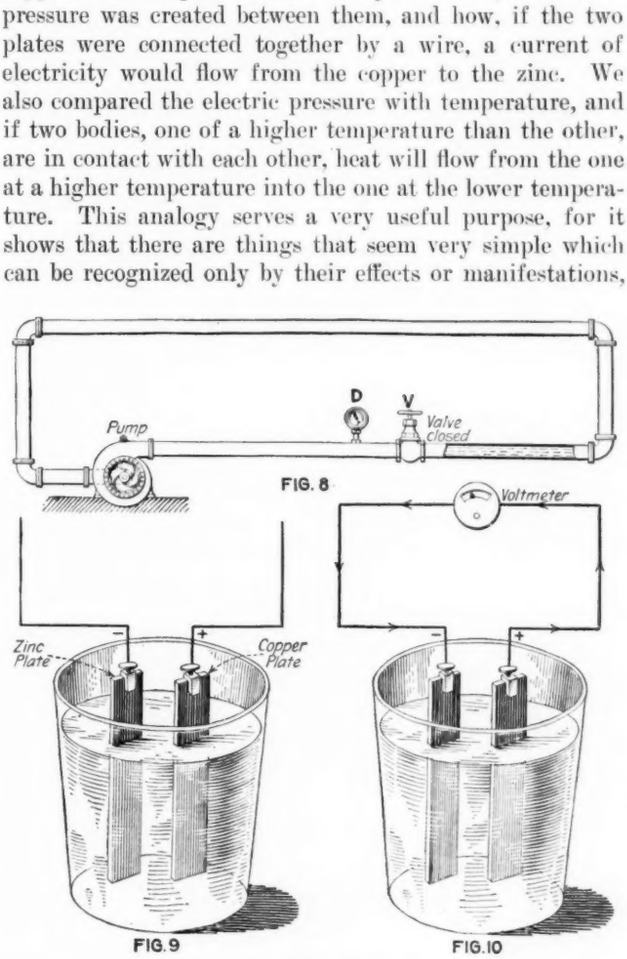
SYNOPSIS—Comparison is made between the flow of electricity from a voltaic cell and the flow of water from a pump through a pipe system. The measurement of an electric pressure and current is considered. Also, how to connect voltaic cells in series to increase the electric pressure. It is pointed out that the scheme is the same as having one pump discharge into another.

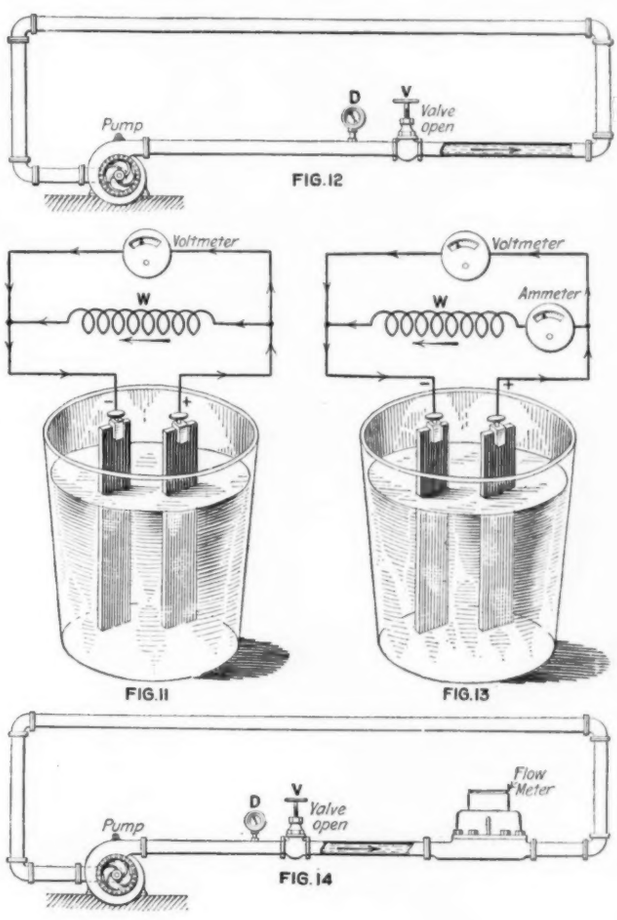
In the previous lesson we found out that by placing a copper and zinc plate in dilute sulphuric acid, an electric pressure was created between them, and how, if the two plates were connected together by a wire, a current of electricity would flow from the copper to the zinc. We also compared the electric pressure with temperature, and if two bodies, one of a higher temperature than the other, are in contact with each other, heat will flow from the one at a higher temperature into the one at the lower temperature. This analogy serves a very useful purpose, for it shows that there are things that seem very simple which can be recognized only by their effects or manifestations, just as an electric pressure or current can be recognized only by its effects and manifestations.

Another analogy of electric pressure and the flow of an electric current is found in a pump and the flow of water through a pipe. As this analogy lends itself most readily to illustrate many of the phenomena in an electric circuit, it will be the one most used in this and future lessons.

In Fig. 8 is shown a centrifugal pump with the suction and discharge connected with a pipe and the system filled with water. If a valve V is placed in the pipe line and closed, driving the pump will not cause any water to flow. All that it would do is to cause a difference of pressure between the discharge and suction of the pump, or, as it might be expressed, a tendency for the water to flow, just the same as a pressure is created between the copper and zinc plates in the voltaic cell, Fig. 9. As long as the plates are not connected externally, an electric current cannot flow. The external opening between the plates serves the same purpose as the valve in the pipe line.

In heat, the temperature, or what might be called the "pressure," is measured with an instrument called a "thermometer." In the case of the pump the pressure is measured by a pressure gage, which is shown at D in Fig. 8. The electric pressure of the voltaic cell, or any electric device, is measured by an instrument called a "voltmeter." This instrument is shown properly connected to measure the pressure between the positive and negative terminals of a voltaic cell in Fig. 10. The principle that the voltmeter operates on will be considered in a later lesson. To measure the pressure of an electric circuit the instruments must always be connected as shown in the figure; namely, one terminal of the instru-





FIGS. 8 TO 14. COMPARE THE FLOW OF AN ELECTRIC CURRENT THROUGH A CIRCUIT WITH THE FLOW OF WATER FROM A CENTRIFUGAL PUMP AND PIPE LINE

ment is connected to the positive and the other to the negative of the voltaic cell. This is true in all cases; it does not make any difference whether it is an electric generator or a power or lighting circuit. If we wish to measure the pressure between the terminals, the voltmeters must be connected as in Fig. 10.

If the positive and negative terminals of the voltaic cell are connected with a wire *W*, as in Fig. 11, a current of electricity will flow, just as a current of water would flow around in the pipe system if the valve *V* is open as in Fig. 14. Comparing Fig. 13 with Fig. 14, it is at once apparent that the flowmeter is connected in the pipe line in a way similar to that in which the ammeter is connected in the electric circuit. In either case the flow is directly through the instrument.

Since we have found out how to produce an electric pressure and current, the next thing is to know how to increase or decrease the quantity. The pressure of a voltaic cell is approximately two volts, irrespective of the size. Therefore, if it is desired to have a greater pressure

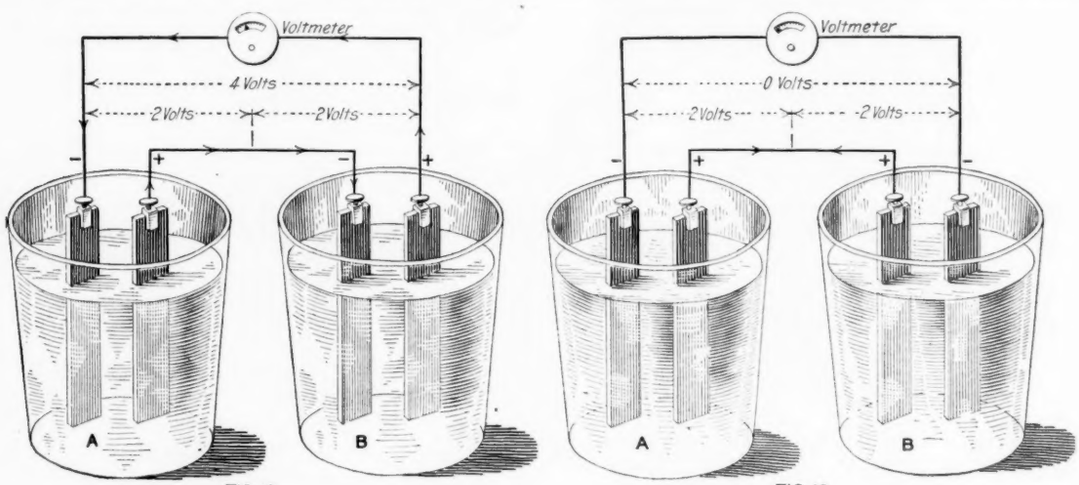


FIG. 15

FIG. 16

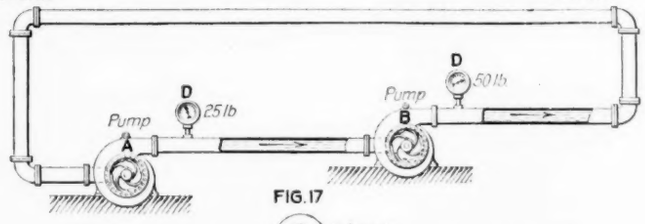


FIG. 17

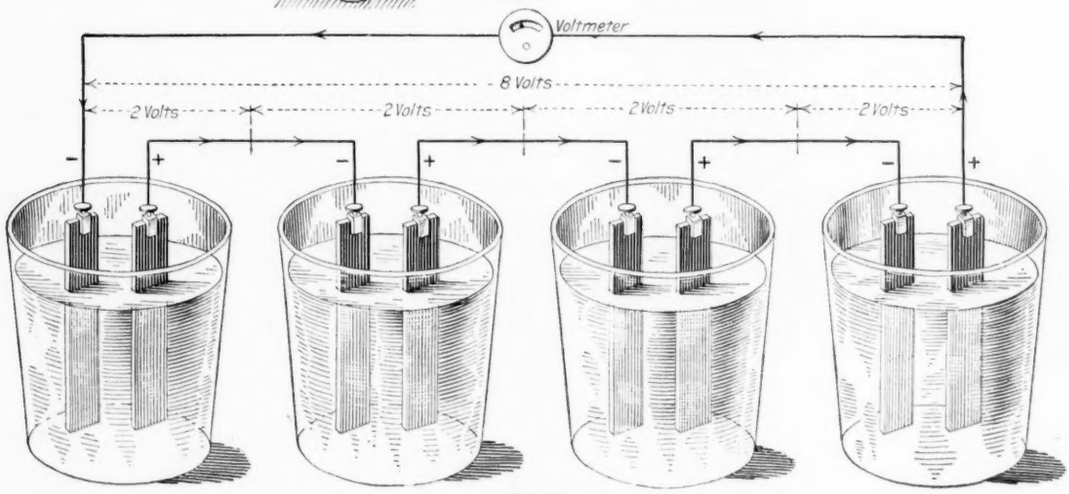


FIG. 18

FIGS. 15 TO 18. ILLUSTRATE A SERIES CIRCUIT

in Fig. 12. To measure the flow of an electric current in a circuit, what may be called a "flowmeter" is used. This instrument is known as an ammeter (meaning ampere meter) and is shown properly connected in the circuit in Fig. 13. It will be seen that the ammeter is connected so that the current flowing through the circuit must also flow through the instrument, whereas the voltmeter is connected directly to the positive and negative terminals. If we wished to measure the water flow in the pipe line, a flowmeter would be connected in the system, as shown

than two volts, we will have to do something else besides change the size of the cell. A change in voltage is accomplished by connecting two or more cells in the proper relation to each other. For example, to obtain four volts, two cells of two volts each will have to be connected as in Fig. 15. This is known as a series connection. The positive terminal of cell *A* is connected to the negative terminal of cell *B* and the other positive and negative terminals brought out. The arrowheads indicate that the direction of the pressure in each cell is the same. It is

very essential that the cells be connected as shown in the figure. If they were connected as in Fig. 16, no pressure would be obtained between the outside terminals. This is evident when it is considered that the pressure of one is opposing that of the other.

Coming back to our pump analogy, suppose the pump shown in Figs. 8, 12 and 14 is only capable of producing 25 lb. pressure. To produce 50 lb. pressure, two pumps would have to be connected in series, as shown in Fig. 17. In this case pump *A* would deliver the water to pump *B* at 25 lb., where *B* would again increase the pressure by 25 lb. and discharge it into the system at 50 lb. This is frequently done in high-pressure centrifugal pumps; two or more wheels are arranged under one casing in such a way that the pressure produced by one is added to that of the other and is known as a two-stage or three-stage pump.

To obtain more than four volts, more cells will have to be connected in series. For example, in Fig. 18 four cells are connected in series and the total pressure across them is 8 volts. Comparing Fig. 15 with Fig. 19, it will be seen that the latter is an enlargement of the principle involved in the former. A copper plate in one cell is connected to a zinc plate in the next, until there is only a copper and a zinc terminal remaining, and these two terminals are brought out to the external circuit.

Visits of Inspector Brown—XXIV

By J. E. Terman

SYNOPSIS—Brown is shown how to make a diagram of the bursting pressure of boiler shells with riveted seams. When the diagram is completed, Brown finds that it can be used for designing a boiler as well as for determining the safe working pressure.

The Chief and Brown were starting on an inspection trip of several days, and as they were leaving the office, Brown said: "Chief, the evenings at the Franklin House will be awfully monotonous if we haven't anything to do. How will it be if you show me about making the real diagram of bursting pressures that you were telling me about?

That evening the Chief said, after lighting his pipe and getting comfortably seated in an arm chair: "Well, Brown, the diagram we made last of the bursting pressures gave such pressures for cylinders without seams, and those are the kind of pressures given in all the tables I have seen of such values. Now what we inspectors are really interested in are the bursting pressures of the shells of boilers, which are usually constructed with riveted seams, although in some few instances we deal with welded shells, as in the case of 'soda digesters,' but we always have or assume a seam efficiency for the weld or joint."

"I know that," said Brown, "and I tackled the job of getting up several tables to cover the most frequently used shell diameters and plate thicknesses with the usual joint efficiencies, but gave it up as a hopeless job."

"Such a table would need quite a few values to be considered, Brown, but when these are so simply obtained by means of a diagram, the labor involved is not great. I have in my grip a diagram that gives the bursting pressures for cylinders of different diameters, thicknesses and percentages of seam strengths, but I am not going to show it to you yet. I want to see if your reasoning powers are good by having you tell me, with a little aid, how such a diagram may be made. You see, Brown," continued the Chief, "the only way to learn a thing is to dig for it. If I should simply explain this subject to you in the shortest time possible, in two months you would probably have forgotten all the instructions given you, unless you put them into practice immediately. Where is the diagram that we have already made?"

"Here it is," answered Brown, pulling it out of his notebook (see Fig. 1).

"Well, Brown, I want you to tell me how you would go about arranging a diagram for bursting pressures of cylinders with seams, instead of seamless cylinders as shown on that diagram."

After considerable study Brown said that he would have to give it up.

"What do you do with the bursting pressures of solid cylinders in order to obtain similar pressures for cylinders with seams?" asked the Chief.

"Why, multiply by the joint efficiency, Chief."

"All right, Brown. I believe the diagraming of the multiplication table was one of the first things we did to

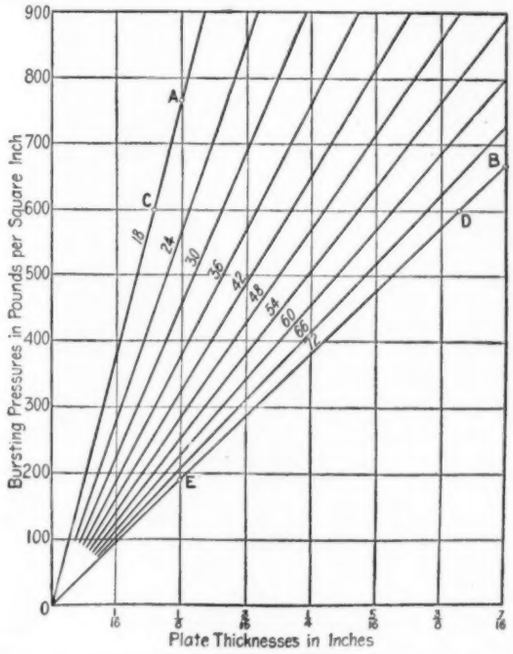


FIG. 1. DIAGRAM FOR BOILER-BURSTING PRESSURE

show the usefulness of this method for obtaining numerical values; was'nt it? The results that you are now looking for must be merely a special form of the multiplication table."

"Oh, now I can see what is to be done, Chief. You will have two diagrams; this one," said Brown, indicating Fig. 1, is to give the bursting pressures of seamless cyl-

inders, and then you will make another one to convert those pressures into bursting pressures where the efficiency of the seam is considered."

"That sounds good, Brown, but I would like you to take this pad and show me just what you mean."

"Well, Chief, I would first obtain the bursting pressure of a seamless cylinder from this diagram," producing Fig. 1, "and have another diagram constructed with these bursting pressures for seamless cylinders on the base line or axis of x, and use the axis of y for representing the bursting pressures of cylinders with seams. If we take 500 lb. as the bursting pressure of a solid cylinder here at A," continued Brown, showing Fig. 2, "and 250 lb. at C as the bursting pressure of the same cylinder with a longitudinal seam applied, the joint efficiency would be 50 per cent. and the diagonal from B to O would represent all the intersections between the vertical lines representing bursting pressures of solid cylinders and horizontal lines representing the bursting pressures of cylinders with seams, where the joint efficiency was 50 per cent."

"Well, how did you know that the 50 per cent. line would pass through O?" asked the Chief. "I did not notice that you arranged a formula for this line on your diagram so that you could tell this."

"No, I didn't, Chief, but I reasoned that one-half times the bursting pressure of the solid cylinder would equal the bursting pressure of the seamed cylinder and that when this last pressure was zero the first must also be zero. The point O was the only intersection that would give such a value, so I knew that the 50 per cent. line must pass through it."

"That is right, Brown. You are improving every day. Of course every other efficiency line on your diagram would pass through O for the same reason. There is but one fault I have to find with the way you propose to make

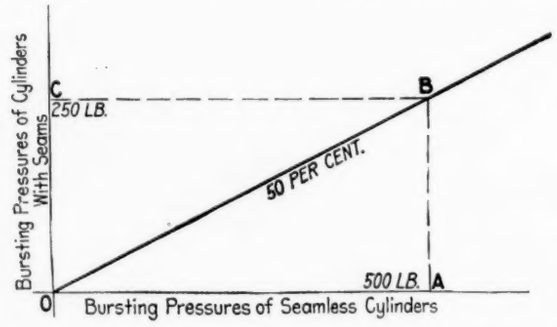


FIG. 2. DIAGRAM FOR BURSTING PRESSURES OF BOILER WITH SEAMS

diagrams to give the bursting pressures of cylinders constructed with seams. Instead of making two separate diagrams, suppose you merely turn the first diagram" (see Fig. 1), "sideways and use the axis of y in that diagram, which will now be horizontal, to represent the axis of x for a new diagram. Also extend the axis of x of the first diagram to make a new axis of y for the new diagram. Now you would have a diagram something like this," said the Chief, drawing Fig. 3.

"Gee! Chief, that is certainly simple! You don't really have to read the bursting pressures of the solid cylinders at all, but just follow the intersections of the plate thickness lines with the required diameter lines over across the sheet to the proper efficiency line and read the actual value of the bursting pressure of a cylinder constructed with a seam along the new y axis."

"Yes, Brown, the bursting pressures of seamless cylinders are not of any particular interest to us, for obtaining them is merely incidental to the determination of the true bursting pressures, which are the values that we are actually after. Since the values of the bursting pressures of seamless cylinders are not required, there is no need for labeling the lines representing them with the figures to represent their value. In this diagram that I have drawn," showing Fig. 4, "you will notice that the values are not indicated for solid cylinders. You will also see that three different working pressures are given, these being for factors of safety of 5, 4½ and 4. It would

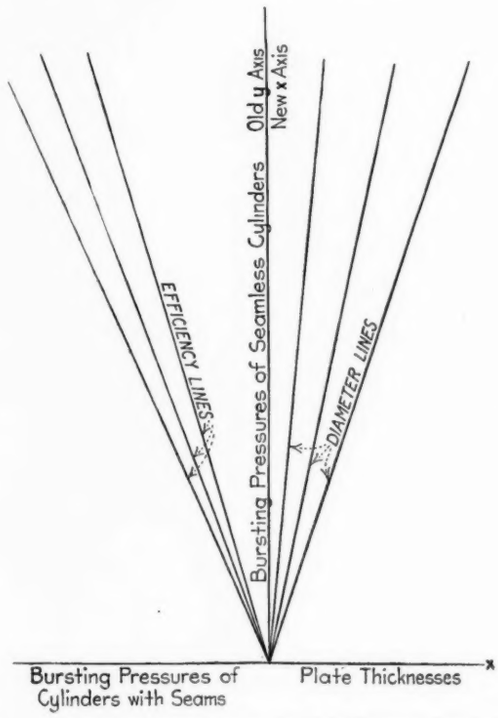


FIG. 3. COMBINED DIAGRAM OF BURSTING PRESSURES

have been possible to have continued this diagram through another section, and by drawing lines to represent the different factors of safety, the required working pressure for any given factor of safety could be directly indicated; but since the range of the factor of safety we use is so small, it is more practical to indicate them as I have done. Suppose we wanted to use this diagram to determine the safe working pressure of those large 78-in. horizontal tubular boilers we inspected today. What was the plate thickness?"

"It was $\frac{9}{16}$ in. thick and the seam was of 92 per cent. efficiency," answered Brown.

"All right," said the Chief, "start here at the right side of the sheet at the bottom on the $\frac{9}{16}$-in. line—that is, the line representing a plate thickness of $\frac{9}{16}$ in.—and follow it up until it intersects the 78-in. diameter line. The intersection is just below one of the horizontal lines. Follow across the sheet to the 92½ per cent. efficiency line and coming back along this efficiency line slightly below the intersection, both because the intersection of the $\frac{9}{16}$-in. plate thickness line and the 78-in. diameter line was a little below the horizontal line that we followed across the sheet and also because the efficiency we are

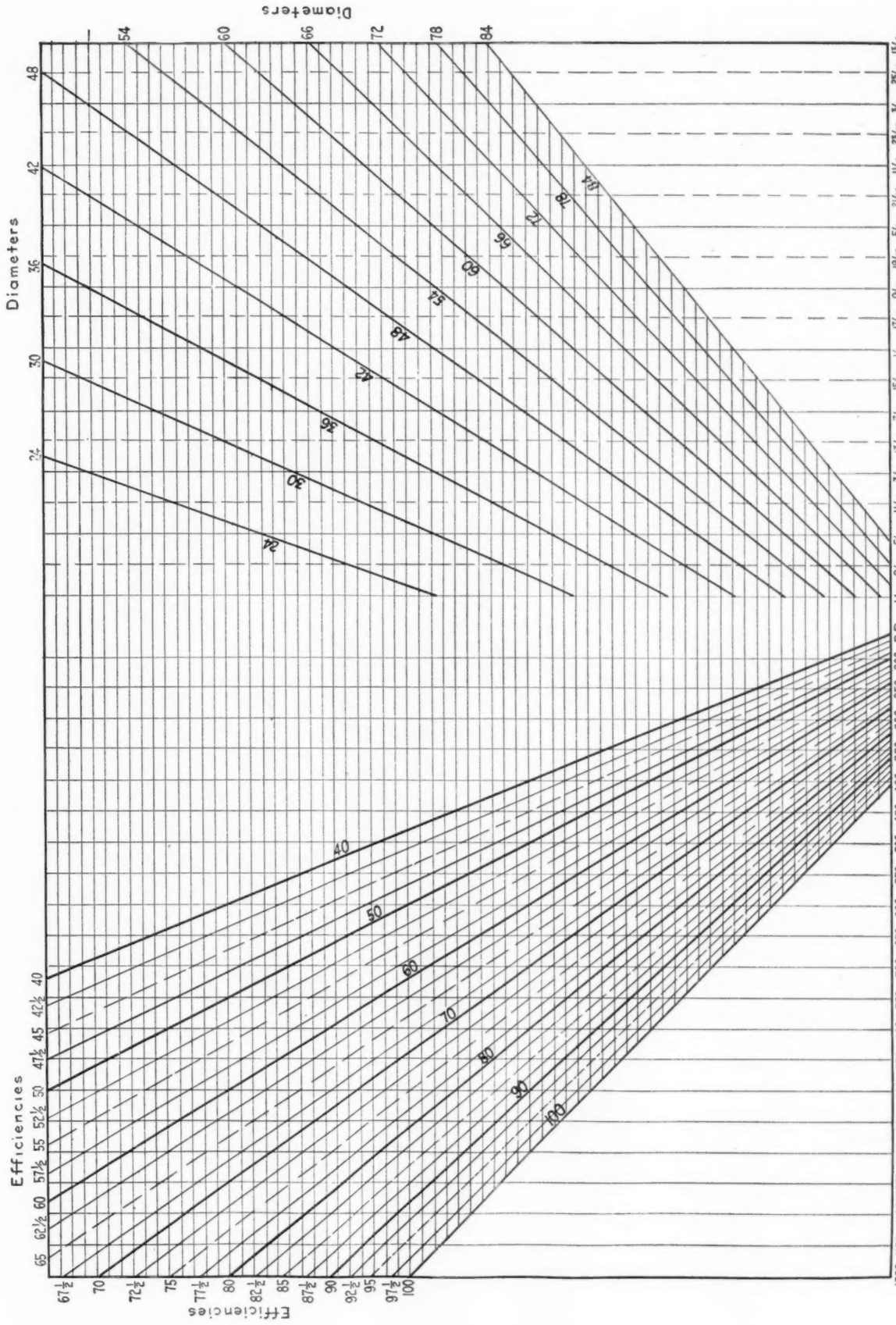


FIG. 4. CHART FOR DETERMINING THE SAFE WORKING PRESSURE OF BOILERS WITH RIVETED JOINTS

dealing with is slightly below 92½ per cent., read the working pressure at the bottom of the sheet for a factor of safety of five. It is seen that the pressure indicated is about 146 or 147 lb. Now check that up, Brown, and see how close we have come to the exact answer."

"The safe working pressure would be the thickness of the plate, times the tensile strength, times the seam efficiency, divided by five times the radius," said Brown.

"That's right," said the Chief. "What would that be equal to in pounds?

"It would be this, then, Chief: $\frac{\frac{9}{16}\times 55{,}000\times 0.92}{5\times 39} = 145.9$ working pressure; and as I make it, the correct numerical value would be 146 lb."

"It would be easier to write the equation $\frac{9\times 55{,}000\times 0.92}{16\times 5\times 39} = \frac{455{,}400}{3{,}120} = 145.9$," remarked the Chief. "It comes out exactly the same, you see. When you are working with a fraction in an equation above the line, as in this case, all you have to do is to drop the denominator below the line and carry out the calculations the same as if the fraction represented ten factors. Should the fraction be below the line, shift the denominator above the line. In either case it is always the denominator that is shifted. This will save a fractional multiplication and is easier to figure. Now, according to your figures we are within a pound of the correct answer, using 147 as the figure shown by the diagram, and I guess you will find that you can always come within two pounds of the correct pressure by the use of this diagram."

"Well, that's close enough in most instances, Chief."

"Now, Brown, this diagram can be used just as well for designing boilers as it can for determining the safe working pressures after they are built. For example, suppose we wanted to know how thick the plate would have to be for a 72-in. shell to carry 140 lb. at a factor of safety of 5. It would first be necessary to assume a figure to represent the joint efficiency, and we will take that at 95 per cent. Starting at the vertical line at the bottom right side of the sheet representing 140 lb. working pressure for a safety factor of 5 and following up this line until the 95 per cent. efficiency line is intersected and then across the sheet until the 72-in. diameter line is intersected and down from this point to the bottom line, it is seen that the thickness required is nearly ½ in.; that is, ½-in. plate would be the least thickness that could be used if the plate thicknesses increased by thirty-seconds of an inch. You will notice on this diagram that the efficiency lines for even tens have been made heavy, while those for 5 per cent. differences have been made dotted. That was done to aid the eye to catch the lines."

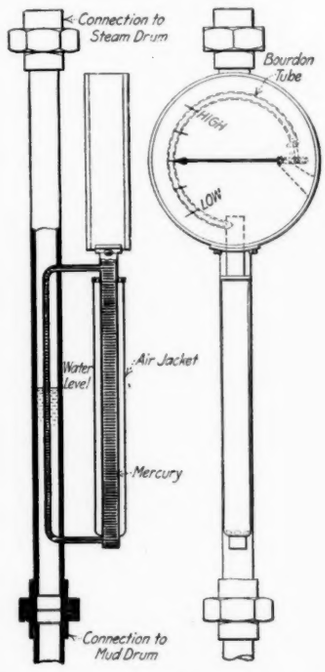
"Gee, Chief! that will save me a lot of trouble. Casey's foreman is constantly bothering me with just such questions as you have answered by this diagram, and I will make him a chart and he can answer his own questions without bothering me."

A Water-Level Indicator for High-Pressure Boilers

By Robert Cramer

One of the most difficult details to design for high-pressure boilers is the water-level indicator. All known types of gage-glasses, tubular as well as flat, have been tested and found useless under pressures above 300 lb. The water level in the water column of the Winslow boiler fluctuates slightly with the load, constantly going up and down a few inches. This heats and cools the glass and causes it to crack, and with the high-pressure (500 lb.) gage-glasses are useless.

The water-level indicator employed at present has the water level in a steel tube. The water and steam surround a small tube connecting on top and bottom with a mercury reservoir. The amount of heat imparted to the mercury from the steam is relatively higher than that imparted from the water, other conditions being equal. The sum of both of these quantities of heat is dissipated to the atmosphere from the surface of the mercury reservoir, and the temperature which this mercury will assume depends on the relative amounts of the inner tube exposed to steam and to water. For a high water level the temperature of the mercury is relatively low, and for a low-water level, relatively high. The temperature of this mercury is indicated either by



HIGH-PRESSURE BOILER WATER-LEVEL INDICATOR

a thermometer inserted into the mercury or directly by means of the expansion of the mercury due to temperature.

The temperature of the surrounding air has some influence on these indications, but not enough to misguide the fireman when he judges the water level by means of the dial indications. It has been found, however, that drafts cause a rapid dissipation of heat from the surface of the mercury reservoir and upset the reading markedly. This difficulty has been overcome by surrounding the mercury reservoir with a brass tube, forming an air jacket. This jacket has circulation holes at the bottom and at the top, and the heat of the mercury well induces a constant, if slight, draft, passing upward through this air jacket, and this action is only slightly influenced by drafts.

Casehardening—There are several ways in which iron or steel may be casehardened. For wrought iron, heat the article to be hardened to a bright red, sprinkle powdered rosin over the entire surface or dip it in powdered rosin so that every part will be thoroughly covered, then plunge the part in cold water. For cast iron the rule is to use prussiated potash, common lye or muriate of potash, heat the part to be hardened to a dull red, being careful not to burn it, and after applying the hardening substance, plunge in clear water. For casehardening machinery or soft steel use potassium cyanide, heat the piece to a cherry red and cover with the cyanide thoroughly. Then reheat to a bright red and plunge in clear water.

Editorials

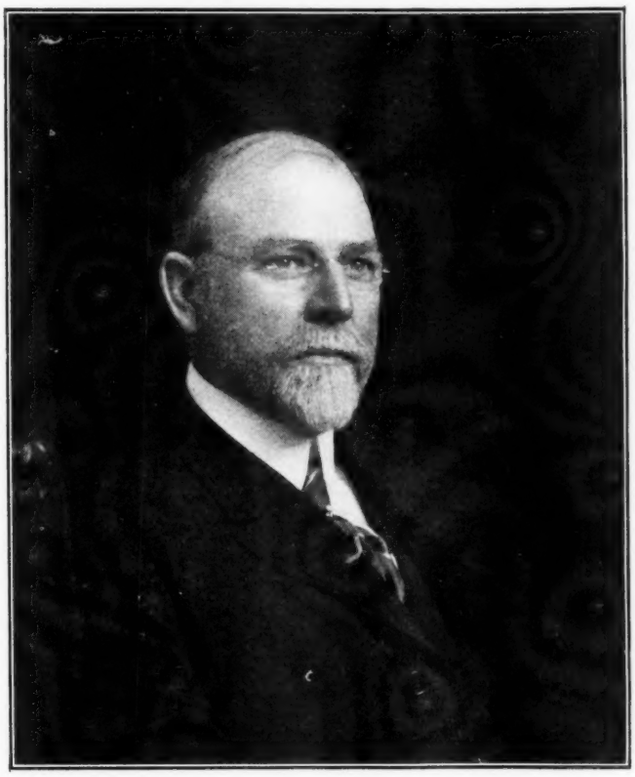
Do You Remember Him?

In the early eighties, when *Power* was a struggling monthly, James H. McGraw gave up teaching a country school and started out to get subscriptions for it.

And he got them.

He got them so successfully that he was sent out after advertisements.

And he got them, too; so many of them that he soon acquired an interest in the company. And the qualities



JAMES H. McGRAW

that had made him a success in the field made him valuable in directing the affairs of the growing concern.

When the writer became editor of *Power* in 1888, this paper, the *Street Railway Journal* and the *American Journal of Street Railway Appliances* were owned by E. P. Harris, H. M. Swetland and Mr. McGraw. After several interchanges Mr. Harris was bought out; Mr. Swetland emerged with *Power,* and Mr. McGraw with the two other papers.

The *Power* Publishing Co., which Mr. Swetland organized, was bought by the Hill Publishing Co. in 1902. The McGraw Publishing Co., ably managed, profiting by the stupendous development in street-railway transportation from the days when horse and cable cars were common to the present era of interurban lines, acquired the *Electrical World,* the *Engineering Record* and other valuable publications, and became the logical complement of the Hill Publishing Co. in the production of engineering periodicals. It was natural that these companies should be consolidated. Following upon the death of the founder of the Hill company, this union has been brought about in the organization of the McGraw-Hill Publishing Co., Inc., the largest publisher of periodical technical literature in the world.

And so Mr. McGraw, who is the president of the new company, comes back to the paper with which he started and sets it in a galaxy of publications controlled by the same wise, fearless and liberal policy that has marked both of the constituent companies. The different papers thus brought under one management cover the entire field of civil, mechanical, mining, electrical and chemical engineering. This joining of means and facilities will give the new company a potency for service to the engineering profession beyond that enjoyed by any other existing institution for the dissemination of information. That such potency will be exerted for the good of the profession the character of the leaders and the history of the constituent papers form a sufficient guarantee.

Where Electric-Light Circuits Are a Serious Menace

In general it is considered that a serious electric shock cannot be received from a one hundred and twenty- or two hundred and twenty-volt circuit. However, if accurate statistics were available, they would show that many electrocutions have occurred on these so-called low-voltage circuits. In the correspondence columns of this issue is a letter that calls attention to three such accidents from a lighting circuit.

Probably the idea that there is no danger of serious shocks from circuits of two hundred and twenty volts and less has grown from the conditions under which these circuits are generally handled. In dry places the average electrician can take hold of the two terminals of a 110-volt circuit without feeling any serious discomfort, and in many cases it is difficult, by this method of testing, to tell whether the circuit is alive. In damp places a different story is to be told, and those who have had experiences of this kind can readily realize what the consequences might be if someone should get across the circuit and for any reason not be able to get away.

Inside of a boiler there seem to be the ideal conditions for getting the most severe shock with the least chance of getting clear of the circuit. The workman is usually well saturated with the metallic and alkali contents that remain in a boiler after it has been blown down, consequently his body and clothing make a very good conductor, and if they happen to come in contact with the exposed part of an electric-light circuit there are the chances of a serious accident, as shown by past experience.

These accidents like most others are easily avoided if proper care is exercised. This means simply seeing to it that the lamp sockets are thoroughly taped up and that

the extension cords are in good condition. It is such a simple and inexpensive matter to make these extension circuits safe, and the results may be so serious if they are otherwise, that there seems to be no reason for such accidents happening unless it is carelessness on the part of the workmen or those who are responsible for the conditions under which the work is done.

Why One Plant Was Shut Down

According to T. I. Jones, in the February Brooklyn *Bulletin*, the Brooklyn Edison Company has increased its power business during last year one hundred and seventy-five per cent. over that for 1912 and fifty-six per cent. over last year. This means that 49,067 horsepower of power business was secured during 1916. The fact that should cause isolated-plant engineers' apprehension is that some of the important contracts signed up during last year, totaling 21,501 horsepower and producing a half million dollars in revenue, were power installations in excess of one hundred and fifty horsepower each.

Of course there is a reason. A satisfied manufacturer is not going to shut down his steam plant for central-station service.

A manufacturer recently gave his reasons for buying central-station service instead of operating his steam plant. One was that although he had recently put in a steam unit of a type known to have a much lower steam consumption than most reciprocating units, it proved incapable of supplying the necessary power. The other reason was that he was tired of the bother caused by his engineer, dishonesty being a factor.

It is understood that considerable reliance was placed upon the judgment of the engineer in the selection of the new unit. If this is so, then he did not measure up to the requirements. He was not capable of handling the proposition, although it was simple in the extreme. As a result the manufacturer expended his money in good faith and when it was too late found out that although the machine was all that was claimed for it, within its capacity, it was altogether too small.

One could not blame him much for counting ten before he again listened to the advice of his engineer and expended more money for another unit that for all he knew would be uneconomical when run in connection with the first one.

This, together with the shortcomings of other engineers, created a condition that opened the way for central-station service without much of a struggle on the part of anyone. The climax came probably when the locker of one engineer was found filled with stolen material belonging to the manufacturer. "Caught with the goods." Here was an engineer that placed a black mark on the entire steam-engineering body, insofar as that manufacturer was concerned.

There is much of importance as regards the foregoing to many engineers. What one central station has done has been duplicated to a greater or less degree by others. This year their gain will be made with a corresponding loss to the isolated plant, and for every one that is discarded one, two or more men are thrown out of employment.

Another item of consequence is the fact that although there are operating engineers who are competent to decide on the size and type of a new installation, there are others that are not. There is no help for any engineer who knows that he is incompetent, if he does not try to enlarge his store of knowledge and fit himself to successfully fill the requirements and demands of his position when the occasion arises.

The Increasing Cost of Coal

All too unhappily, we are aware of the effect of the European War on prices of all kinds. The fuel market is one of those that has felt the increase markedly. Where, before the war, the price of coal was fairly uniform, business conditions being comparatively quiet and the labor situation favorable, the demand from munitions manufacturers for help, as well as the generally greater industrial activity, has made a shortage in labor supply. A natural accompaniment of this situation has been an increase of business for the railroads in the transportation of freight that further helped to heighten the cost of coal as well as all other commodities.

Some of us have consoled ourselves that this situation is only temporary; that after the war is over, prices will return to their former level. Many things will go down in cost, though perhaps far slower than they went up. Coal, however, is unlikely to ever be as cheap again as it was before the war, because we are told that even under normal conditions the demand doubles about every four years. Except in the event of a serious industrial panic, there is little chance that we will ever again buy coal at the prices that obtained three or four years ago.

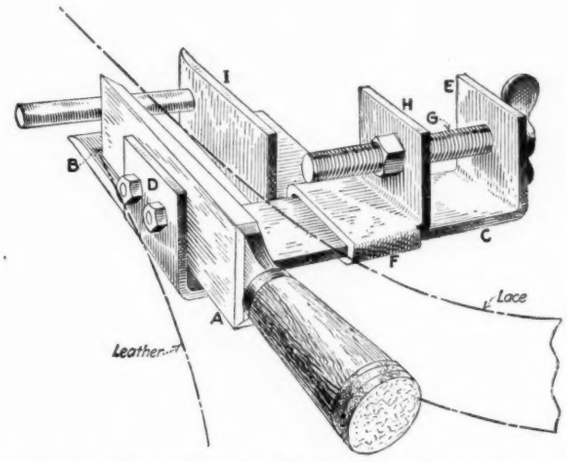
This being true, the importance of economy in the use of fuel is evident, and it behooves every owner of a power plant to be preparing for the time when profits may be smaller. Let a little of the surplus earnings now be applied to the improvement of equipment and the installation of efficient methods of operation; then, when dull times do come, the plant will be in a position to do its share in keeping down expenses. Under the present prosperous conditions we are little given to thinking about economy, feeling that there is no occasion to give heed to anything other than speeding up production to reap the harvest that is now available; but those who are foresighted will appreciate the wisdom of being ready to meet a changed situation, however remote it may seem. Certain it is that if the severance of diplomatic relations with Germany or the ending of the war, bringing the foreign nations back into more active competition with our industries and commerce, should bring about a contraction of our markets and a sharply reduced demand for the output of our factories, there are a great many of our plants that will be forced to shut down or face a period of operation under heavy losses. Those that endure will be the ones that have prepared, and not the least of the directions in which they may do so is in the provision for efficient and economical power-plant operation.

As announced elsewhere in this issue, Prof. R. C. Carpenter will soon retire from Sibley College after nearly thirty years in the teaching profession. The engineering world will welcome the fact that he is to continue his activities in experimental work, in which he has long been a recognized authority. Thus relieved of the teaching routine, much may be expected from the remaining years which his splendid physique promises to make long and fruitful.

Correspondence

Gage for Splitting Belt Lace

A practical device for splitting belt laces can be easily and quickly made as follows: It consists of three principal parts. *A* is a knife or wood chisel sharpened at the end and cuts with the front edge *B*. It is fastened



CUTTING LACE OF DESIRED WIDTH FROM LEATHER

to the bent-up part of *C* (marked *D*), which is made of brass or iron plate. with two small bolts. The opposite end *E* is likewise bent up, after *F* has been slid on, and has a hole for the adjusting screw *G*. The third part *F* is made so that the loop *F* can slide over *C*, and part *H* also has a hole for the adjusting screw. A guide *I* for the side of the leather has a top guide, which serves to keep the leather down flat.

The leather is placed on the floor or bench and the screw *G* adjusted to the desired width of the lace. A cut 3 or 4 inches long is first made in the leather the width of the lace and serves to get a right start. This part of the lace is put between the knife and the guide, and the leather is held with the left hand while the right hand pushes the device forward, raising the leather slightly from the bench. B. Z. REITER.

Hoboken, N. J.

Protecting Electric Machines Against No-Voltage

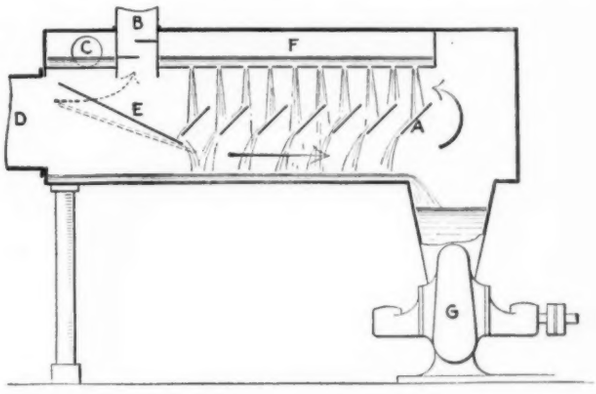
I read with much interest H. M. Phillips' article on "Protecting Electric Machines Against No-Voltage," in the Feb. 13 issue of *Power*. I have had some experience with such unprotected machines that may be of interest. A 75-hp. motor was installed in a room below the engine-room floor; it was out of sight of the engineer and carried a heavy overload. The station circuit-breaker tripped out one night, and when the operator threw the switch back in of course the motor had stopped, and it was badly burned when the current came on. Smaller fuses were put in, but were a source of trouble, as they would often blow when the motor took on a sudden overload.

In another case a line was run from a generating station to furnish 1200 hp. to a motor seven miles away. It was a common thing to have the circuit-breaker go out. One night the circuit-breaker opened, and when the operator tried to put the switch back in, the line showed a dead short. He called up the mill, and the men informed him everything was all right there, consequently he decided that the trouble was on the line. In the morning the trouble men went the whole length of the line and reported everything clear, but the line still showed a short-circuit. An operator was sent to the mill and found that the motor switch had not been opened, and that a block of wood had been fitted on the plunger of the circuit-breaker so that it could not operate. The expense caused by these troubles would have more than paid for the extra cost of installing a no-voltage release on these motors. V. C. WOOD.

Copenhagen, N. Y.

Locating Condenser Trouble

A rectangular spray, or "rain-pipe," condenser connected to a 750-kw. low-pressure turbine had not been giving good results for a long time. The discharge wa-



BAFFLE PLATE DISPLACED IN SPRAY CONDENSER

ter would heat more than it used to for the same load, with a corresponding loss in vacuum (about 2 or 3 in.); and the turbine would carry only 600 kw.

One plan after another was tried with very slight improvement. The cooling tower also served a 1000-kw. turbine. The piping, the condenser and the turbine casing were carefully gone over for leaks, and a few small ones were found and stopped, which gained about half an inch of vacuum, but these gains did not seem to be lasting. The impeller of the pump was changed, the old one being slightly corroded, but this made only a slight gain, which was also soon lost.

Thinking air might be coming in with the low-pressure steam, the turbine was tried on high pressure with no better results. The water intakes to the condensers were 18 in. apart and submerged 3 ft., and upon examination while in operation the water showed eddies that drew air into the suction line, therefore they were changed so as to be 15 ft. apart and submerged 4 ft. This stopped the eddies and helped the vacuum about half an inch. The condenser was examined inside, and although several of the baffles marked *A* were found lying on the bottom, replacing them did no good. About two weeks ago the vacuum suddenly dropped 2 in. more, or 4 in. below what it should have been to correspond with the injection-water temperature, and the turbine could carry only half of its load. The air-pump cylinder, which had been running warmer than it should, got very hot and discharged considerable steam.

The illustration shows the interior construction of the condenser and will help in explaining where the trouble was finally located. Water enters at *C*, passing into chamber *F* and falls on baffles *A* and from thence to the bottom and to the pump *G*. Steam enters at *D*, passes under the baffles *E* and *A*, through the sheets of water, and any steam that is left, together with the air, passes between *A* and *F* to the air-pump suction *B*.

It was found that the heavy baffle *E* had dropped 6 in. and allowed the steam to "short-circuit" directly into the air intake *B* and the air pump, causing the high temperature noticed and preventing it from handling the air. When the baffle was replaced so all the steam had to pass under it and through the water, the trouble was cured, the vacuum came up to normal and the turbine could pull its full load. The 2-in. drop had cut down the output of the turbine 150 kw., which cost about $10 per day, as it had to be generated by the high-pressure units and therefore was an important matter. I hope this may help someone who has similar trouble.

Youngstown, Ohio. LEO. F. GRANDMONTAGNE.

Feeding Return-Tubular Boilers

I have been following with a great deal of interest the discussion on the proper place for feed water to enter boilers, as this has always been a pet hobby of mine and something to which I have given much study; but I have not yet seen anything that I agree with as "just the right place."

We have been taught that the feed water should be discharged at the coldest place in the boiler, and that, to my notion, is over the top row of tubes near the front head. My reason for believing this the coldest place is that the furnace temperature is approximately 2000 deg. and there is a very small drop between the furnace and the back uptake, but from there the gases turn into the tubes with a rapid drop of temperature, finally reaching the stack at about 500 deg.

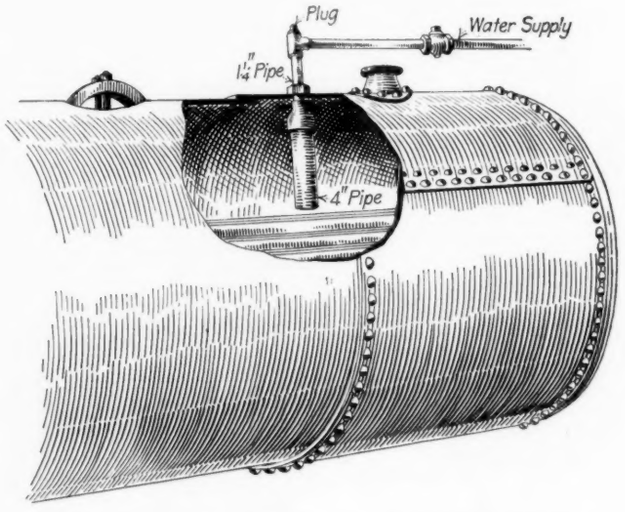
My method of piping is through the front head. Let the pipe extend nearly to the back end of the boiler, return to within about 18 in. of the front head and then discharge into a pan just below the water line. The pan is desirable as it can be taken out at each washing time and emptied of the solid matter that it may contain. The long travel through the pipe will bring the temperature of the incoming feed water practically to that of the water already in the boiler.

This will not eliminate scale, but the feed water will be taken up by the water already in circulation and instead of depositing a heavy lot of scale in one place, it will have a tendency to distribute it more evenly, which in itself is a big advantage. Some of your readers may offer the objection that the cold water will be directly over the fire, but there is a considerable body of water between the fresh feed water and the fire.

Memphis, Tenn. JOHN STOCK.

After reading the experience of other engineers in boiler-feeding I will give mine along that line.

I have three 60-in. by 16-ft. tubular boilers that are now fitted up alike and the results are identical, but previously I was troubled with scale and sediment settling on the fire sheet over the fire or the bridge-wall. I had the boilers fitted up with the feed pipe entering through the front head at the bottom near the fire sheet, but this was not satisfactory. I then used a brass pipe entering above the fire tubes, running back 8 ft. The pipe was



A SATISFACTORY METHOD OF FEEDING BOILERS

capped and had two rows of ¼-in. holes drilled on the lower side. This was a failure, as it soon filled up with lime. A wrought-iron pipe uncapped proved to be no better. The next change was to run the pipe to within 2 ft. of the rear head crossed over looking down (Hartford Insurance company's style), but this was no improvement. I then fitted up the feed through the blow-off. After trying these various methods and finding them all unsatisfactory, I put in a top feed 3 ft. from the back head with a 1¼-in. pipe emptying into a galvanized-iron pan 2 ft. long, 15 in. wide and 2 in. deep, but this was no improvement.

Finally, I removed the pan and pipe and put in a 4-in. pipe with a reducer at the upper end connected with a ¼-in. pipe and extending down to within 2 in. of the tubes; on the outside I have a tee plugged at the vertical end, which I find handy for cleaning the pipe inside the boiler, which is exposed to steam and accumulates scale so that it needs to be bored out once or twice a year. This is easily and quickly done by removing the plug and using a drill or a chisel.

This feed has been in use for over twenty years, and the 4-in. pipe has been removed and cleaned only once during that time. The scale and sediment, instead of being deposited over the fire as formerly, are packed solidly in between the rivets on the front head and extend up each side about one-third of the diameter of the boiler. The 4-in. pipe has another good feature; that is, when the water gets below its lower end, or within 2 in. of the tubes, the cold water coming in contact with the steam sets up a racket that is the best kind of low-water alarm. When this happens, I shut off top feed and feed through blowoff.

I have another kink that I think worth while. The boilers are fitted with high- and low-water alarm columns that have two sets of openings, on opposite sides, for gage-cocks. I removed the top plug and fitted in its place a 3/8-in. vertical check opening inward so that when the boiler is being emptied the check will open and let air in and break the vacuum. When getting up steam, it will let out the air until there is 3 or 4 lb. pressure on and then it will close. I have a similar "snifting valve" on the main steam line for the same purpose.

Sterling, Ill. A. W. Wilson.

Boiler-Room Electrocutions

Recently a man was electrocuted in Bloomington, Ill., while using an electric lamp on an extension cord when working in a boiler. The man was found dead lying upon the metallic structure of the boiler with the extension cord in his hand. The supply was the ordinary lighting circuit of about 112 volts, protected by fuses in the usual way, and such as is generally considered safe. One side of the circuit was grounded, a mandatory practice in many localities. The idea of grounding one side of the low-voltage circuits—that is, circuits below about 250 volts—is that, should failure occur between the high- and low-voltage windings of the transformer or should the high-voltage wires come in contact with the low-voltage wires, the fuses at the entrance to the building would immediately blow in case a ground exists on the high-voltage circuit, thus isolating the dangerous voltage from inside of the building. While grounding one side of the low-voltage circuit is a protection against high voltage on the former, nevertheless it must be apparent that should accidental contact be made with the ungrounded conductor, the liability of receiving a shock is greatly increased. Whether an electric shock is injurious, neglecting the effect of suddenly contracting or expanding the muscles, overbalancing and falling, the magnitude of the current and the path it takes are the criteria as to whether dangerous results follow. The condition of the skin, whether dry or moist, perspiration, etc., also is an important factor affecting current flow.

A pressure as low as 112 volts is generally considered safe, especially if the skin is dry and the heart normal, provided the current flow is for an instant only. However, a common-sense precaution is to avoid making contact between electrical fixtures and conductors and water pipes, radiators, water faucets and their equivalent, because they constitute about the best "earth," or ground, connection obtainable. Boilers invariably act as good earth connections, because of their connection with the water pipes and other extensive steel structures, and thus contact between charged conductor and boiler may be expected to bring the most pronounced results. To go inside a furnace or stand on a boiler, the contact area being improved by carbon and the resistance to current flow being lowered by probable perspiration and dirt, seems favorable to electrocution, as happened in the present instance, whether one's heart is normal or otherwise.

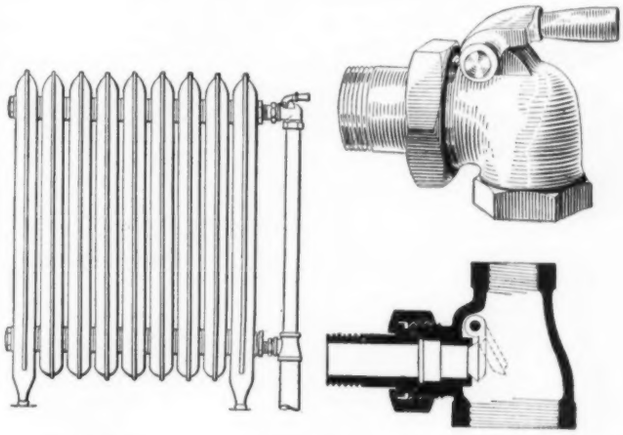
About eight years ago two men were working together in a furnace chamber of a large boiler plant with the writer. We were using two extension cords on a 120-volt circuit. One of the cords was defective and electrocuted one of the men, and also the other in going to the rescue of the first. A lesson like this is not easily forgotten, and the moral cannot be repeated too often. Low-voltage circuits are not necessarily safe; treat them as if they were not, rather than the reverse. Do not use extension cords around metal that is solidly grounded without exercising care that the cord and socket are properly insulated and in good condition. Many wrappings with friction tape cost little and may prevent serious accidents.

Chicago, Ill. R. K. Long.

Radiator Piping System

In the issue of Jan. 9, page 58, Mr. Grahame says that with a gravity system it is almost impossible to vary the temperature of the radiators, etc., and that most gravity systems are noisy at times, especially when turning on steam. As he does not qualify his statement, I assume that he means the one-pipe class and is therefore correct, and this is attributable to two causes—one physical, the other conventional.

In ordinary one-pipe work the supply valves are placed at the base of the radiators and their function is twofold—they are avenues for the heating vehicle and in addition for the return water of condensation. Therefore they cannot be adjusted to furnish a lesser amount of steam and permit heat modulation, but must be either fully opened or tightly closed; and failure to close the valve tightly, or a leaky valve, will always induce an upbuilding of condensation that floods the radiator, occasionally drawing a dangerous amount of water from the boiler. Furthermore, when the supply valves are opened, the accumulated water in attempting to pass the incoming rush of steam produces a noise, or water-hammer.



NEW DESIGN OF RADIATOR INLET AND OUTLET VALVE

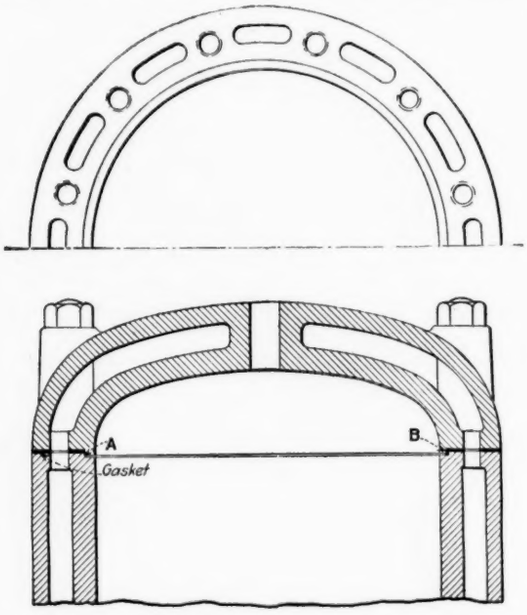
The inability to regulate the steam supply to heating units and thus modulate the temperature is one un-

satisfactory feature of the ordinary one-pipe job. There is, however, no valid reason for perpetuating this unfavorable practice, for with proper accessories this desirable feature of heat modulation may be accomplished with an improved form of construction. That is, if the dual function be divided between two separate fittings, each having its own office, it will be possible to obviate the objectionable features. The illustration shows a new design of steam-supply valve and an automatic return valve, recently patented by me. The steam supply passes through the controlling valve, which can be adjusted to furnish steam to full capacity or any fractional part necessary to meet varying weather conditions. The water of condensation flows out through the automatic return valve and returns by gravity, the steam being excluded from entrance by the peculiar construction of this fitting so that the friction of opposing currents is eliminated, circulation is improved and the operation is noiseless at all times. The condensation maintains a slight static head in the radiator at all times whether the supply valve is open or closed, and as there is never any retention of condensate beyond that noted, there is consequently no sudden release of entrapped water to greet a supply of steam and cause water-hammer.

Schenectady, N. Y. E. L. DAVIS.

Oil and Gas-Engine Cylinder-Head Joints

While trying to locate trouble on a semi-Diesel oil engine, I found that the explosion or ignition pressure in the cylinder caused leakage into the water-jacket space



TYPE OF JOINT AND GASKET

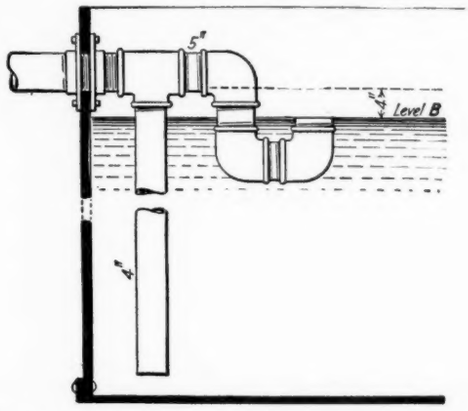
past the copper gasket joint made, as shown, with openings for water to pass between the head and the cylinder jacket, the joint being of the male-and-female type. While the head seemed sufficiently strong, it was impossible to pull up tight enough on the studs to prevent leakage. Other operating engineers told me they had experienced the same difficulty. I filed the circumference of the projection on the head at *B*, beveling it slightly, and made a new copper gasket with the inside diameter of hole smaller than that in the gasket furnished by the engine builders. Upon tightening up on the nuts, the gasket was turned over, or flanged, around the cylinder and this eliminated the trouble, as it made a good joint on the flat surface and an angle joint where it was squeezed between cylinder and head. C. A. MERTON.

Pittsburgh, Penn.

Removing Sediment from Tank

The overflow described by J. A. Suess, in the issue of Jan. 23, page 124, calls to mind an arrangement I saw some time ago. The overflow takes water from the bottom, as described, but it also takes some from the surface (skims the water), and the pipe forms a trap and prevents the escape of sewer gas.

The overflow is 5-in. threaded pipe on the U end and 4-in. on the drop pipe. When there is a small overflow the water is all taken from the bottom of the tank, but



SURFACE AND BOTTOM OPENINGS TO OVERFLOW

when there is a heavy overflow it starts the siphon and the water is largely taken from the surface of the tank for a depth of 4 in. at a time, taking most of the floating pieces, leaves, etc., with it, and the siphon breaks, at level *B* so that the overflow is always sealed.

Portsmouth, Ont., Canada. JAMES E. NOBLE.

Freeing Valve Stem Threads

I quite agree with Mr. Coleman (page 262, Feb. 20) that using reasonable care and a little oil on the threads of valve stems will prevent them from "freezing" or sticking, yet in a plant where there are many valves that are seldom used, some give trouble even when given a share of attention, and some are so located that it is impossible to give them proper care.

A valve sometimes sticks because the stem has been oiled and not for the want of it, as the oil carries a little coal or dust into the threads of the yoke, where it becomes baked. Bronze stems in steel yokes are sometimes made "too good" a fit, and when the stems expand by the heat, it is impossible to move them, yet when cold they turn easily. The drippings from a leaky packing gland, if allowed to continue for service reasons which will not permit cutting out that particular section of line to repack, will cause stems to stick, so that my suggestion in the issue of Jan. 16, page 26, seems after all to have some sensible value. H. C. WILLIAMS.

Concord, N. H.

Inquiries of General Interest

Sloping Line for Boiler Try-Cocks—Why are the try-cocks in the head of a return-tubular boiler placed on a sloping line? R. G.

By placing the try-cocks along an inclined line they may be set with smaller differences of level without interference of position or operation and with less annoyance from the discharge of upper cocks falling on lower ones.

Current and Potential Leads in the Same Conduit—What objection is there to placing the current and potential leads of polyphase meter transformers in the same conduit? T. A. B.

There should be no objection to this practice. However, there is a slight mutual inductance between the leads of the different transformers, but this is so small that its effect will not be noticeable on the meter registration.

Efficiency Required for Longitudinal Joint—What efficiency of longitudinal joint would be required for a cylindrical boiler shell, 66 in. diameter, to carry 100 lb. pressure per square inch with a factor of safety of 5, if made of ⅜-in. plate of 55,000 lb. tensile strength per square inch of cross-section? E. C.

The solid plate with a factor of safety of 5 would be capable of resisting a pressure of $\frac{2 \times 55{,}000 \times \frac{3}{8}}{5 \times 66} = 125$ lb. per sq.in., and for 100 lb. per sq.in. the efficiency of the joint would need to be 100 ÷ 125, or 80 per cent.

Operating a Polyphase Alternator Single-Phase—What would be the effect of operating a polyphase alternator single-phase? F. A. A.

This will depend upon the construction of the machine. If the rotor is of the solid-steel type without a damping winding, the heating of the field core will be excessive. In some cases three-phase alternators are built to operate single-phase to supply railway loads. In all the machines for this purpose the rotors are laminated and equipped with a heavy squirrel-cage copper structure for overcoming the heating effect, and also to help distribute the load between the three phases.

Boiler Setting for Burning Sawmill Waste—What is the best form of setting a return-tubular boiler for burning sawmill waste? Should there be a deep combustion chamber back of the bridge-wall? G. H. B.

The most successful setting is one that provides a furnace wherein the combustion is completed before the gases come in contact with the heating surfaces of the boiler, and for that purpose an inclosed or "dutch oven" type of furnace is found to give the best results. Deepening the combustion chamber of an ordinary setting would be of little benefit excepting to afford more space for accumulation of ashes and imperfect combustion of light particles of the fuel that may be swept from the furnace by the draft.

Spring-Loaded Safety Valve Without Blowdown—How would a spring-loaded safety valve operate if there is no lip or blowdown ring? R. E.

In blowing off, the valve would close almost as soon as the boiler pressure was reduced to the blowoff pressure for which the valve was loaded; that is, there would be little or no "blowdown." When the valve is provided with a lip or blowdown ring, the back pressure of the escaping steam assists the boiler pressure in overcoming the load on the valve and the valve is held from its seat until the boiler pressure is reduced below the initial blowoff pressure, the amount of "blowdown" depending on the form of the valve and the adjustment of the relief or of the blowdown ring.

Approximate Power of Engine—What power is developed by a 16x18-in. noncondensing engine running 150 r.p.m., cutting off at ⅜ of the stroke when supplied with steam at a pressure of 90 lb. gage at the throttle and exhausting against 2 lb. back pressure? W. L.

To estimate the power, the m.e.p. must be known from steam-engine indicator diagrams taken from both ends of the cylinder. Otherwise it is necessary to know the percentage of the clearance and assume the actual initial and average admission pressure from which to compute the average pressure realized during expansion after cutoff, and also assume the point of release, actual cylinder back pressure including back pressure from compression of the exhaust and also assume the effects of cylinder condensation and valve and piston leakage. Under average working conditions the m.e.p. realized would be about 45 lb. and the engine would develop about

$$\frac{45 \times (16 \times 16 \times 0.7854) \times \frac{18}{12} \times 2 \times 150}{33{,}000} = 123.38 \text{ i.hp.}$$

Common Receiver of Returns from Laundry Machinery—In place of providing individual traps for calendars and other laundry machinery, could not the return pipes be connected to a common receiver discharged by a single trap? C. P.

Employment of a common receiver of returns from two or more steam-heated machines is impractical unless the returns can be discharged into the receiver at the same pressure. The pressure of returns from laundry machines is usually variable, especially when starting up the plant. More or less trouble is likely to be experienced from poor drainage unless the return pipes from each machine drop separately through a height of about 25 ft. before being connected together or to a common receiver, so as to provide for a discrepancy of pressure of about 10 lb. per sq. in. When the difference of pressure is not thus compensated by sufficient independent drop of a return connection, its drainage will require a stop and bypass to the atmosphere or to a separate trap.

Advantages of Compounding—What are the advantages of using steam expansively by compounding in place of performing all the expansion in a single cylinder? J. M. G.

When saturated steam is expanded more than four or five times, there is considerable range of temperature and loss from condensation. When high-pressure steam is first expanded in a small cylinder and then conducted at lower pressure into the main cylinder and there expanded to the desired terminal pressure, the temperature range is less in each cylinder and the hotter steam is brought in contact only with the smaller areas of the first, or high-pressure, cylinder. Other advantages are that in effecting the whole expansion in a simple engine, the large ratio between the initial and terminal pressure causes greater fluctuations of energy and of stresses, requiring a heavier flywheel; and where the cross-compound type of engine is employed with cranks at 90 deg. apart, the turning effort is more uniform and the engine runs more smoothly than with a single-crank engine.

Higher Initial Pressure for Higher Back Pressure—If an engine with 5 per cent. clearance and cutoff at ¼ stroke operates against a back pressure of 2 lb. gage when the initial pressure is 100 lb. gage, how much would the initial pressure have to be increased for the same load and same point of cutoff if the back pressure is increased to 7 lb. gage? A. R. K.

The same load will require the same m.e.p. By referring to a table of "Mean Pressure per Pound (absolute) of Initial Pressure," such as given on page 115 of Low's "Steam Engine Indicator," it may be seen that for ¼ cutoff and 5 per cent. clearance the average pressure would be 0.6258 lb. per pound of absolute initial pressure. Hence for an initial pressure of 100 lb. gage, or 114.7 lb. absolute, the theoretical average pressure would be 0.6258 × 114.7 = 71.78 lb. per sq.in., and with a back pressure of 2 lb. gage, or 2 + 14.7 = 16.7 lb. absolute, the theoretical m.e.p. would be 71.78 — 16.7 = 55.08 lb. But from falling off of the initial pressure during admission, condensation and early release during expansion and compression of the exhaust, the theoretical m.e.p. is never realized. If the ratio of the actual to the ideal is assumed to be the same for 2 lb. as for 7 lb. back pressure, then in the latter case the back pressure of 7 + 14.7 = 21.7 lb. per sq.in. absolute would require 55.08 + 21.7 = 76.78 lb. m.e.p. As with ¼ cutoff and 5 per cent. clearance each pound of initial pressure results in 0.6258 lb. mean pressure, 76.78 lb. mean pressure would require an initial pressure of 76.78 ÷ 0.6258 = 122.69 lb. absolute, or about 108 lb. gage, and therefore the initial pressure would have to be increased 108 — 100 = 8 lb. per sq.in.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

The Hauck Ammonia Explosion

At a little after 2 p.m. Wednesday, Feb. 28, an explosion in the refrigerating plant of the Peter Hauck Brewing Co., Harrison, N. J., killed John Flynn, the engineer, and did slight damage to the property.

The plant is an old one, having been in service well over a score of years. Originally it was the De La Vergne oil system (compression), but changes lately made converted the compressors into dry-system machines. A cast-iron vessel, Fig. 1, approximately 14 in. by 8 ft. and 1 in. thick, used as part of the wet compression system, was continued in service in the discharge line, acting as an oil separator. The engineer on the 3 to 11 o'clock watch was assigned the job of emptying this separator of oil, and a representative of "Power" was assured by the chief engineer that this was done. The condenser room is on the floor above the compressor room.

The engineer was pumping back at the time of the explosion, there being about 10 in. vacuum on the suction side. The normal head pressure is 120 lb. There were, evidently, two simultaneous explosions, one in the vessel referred to as an oil separator and one in the gas line in the condenser room. The bottom head of the vessel (not welded) was blown off, also a heavy bracket supporting the vessel. The explosion in the gas line was violent, as will be seen from Fig. 3, the pipe being split into three strips. Unfortunately for the engineer, who was in the condenser room at the time of the explosion, the pipe let go between the condenser and a check valve, which would open to allow passage to the condenser, but not in the other direction. The charge of ammonia was therefore lost, the engineer being overcome before he could go the 18 or 20 feet needed to reach comparative safety in the next room, which is very large. The plant has a total capacity of 275 tons, roughly, and had many hundreds of pounds of ammonia in the system. The violence of the explosion of the separator blew out all windows and doors in the compressor room. Two men working at the bench shown, which is in a direct line with the separator and not 20 feet away, escaped with trivial injuries, though the cock and head and piece of bracket shown in Fig. 2 landed at their feet. No safety valves were used in the discharge or other lines in the system.

One is led to conclude after investigation that the explosion resulted from the ignition of the explosive mixture formed by the oxygen of the air, which likely leaked in during the period of pumping down, and the hydrocarbon gas from the hot cylinder oil, and also the hydrogen in the ammonia. So far as those in the plant know, the head pressure did not increase above normal; but the mixture was ignited somehow—whether by excessive temperature due to pressure or by scale or dirt in the system causing a spark, no one knows; one can only surmise.

Two lessons are to be learned from this explosion: If safety valves had been provided, as legally required by Massachusetts, for example, vented to the atmosphere, these might have allowed relief for the pressure. It suggests, too, the advisability of locating the check valve in the discharge line, right at the condenser and not a score or more feet farther back in the line, as this one is located. Secondly, while the exits are as numerous and clear as one generally finds them, the explosion suggests a direct and unrestricted passage—a safety stairway—from the condenser room to the outside air. In this plant there are two exits from the condenser room, but to use either, when time is so vital a factor on account of the quick action of the ammonia, is to meet certain death before safety is reached. To use one, the operator must climb over or continue on over the condenser if he is on top of it, as Flynn did. To use the other, shown in Fig. 4, he must reach the floor of the compressor room by climbing down the slippery iron stairway leading to the platforms on the vertical compressors and thence to the floor level by another stairway of like character. This latter route will ordinarily lead him into the danger zone instead of away from it.

There is rumor of an ammonia safety ordinance being passed by the town council.

PERSONALS

Alfred D. White, formerly district engineer of the Green Engineering Co., at Denver, Colo., is now with the Illinois Stoker Co., Alton, Ill.

George A. Wardlaw, editor of the "Electrical Record" since 1910, resigned that position on Mar. 1 in order to engage in free-lance literary work.

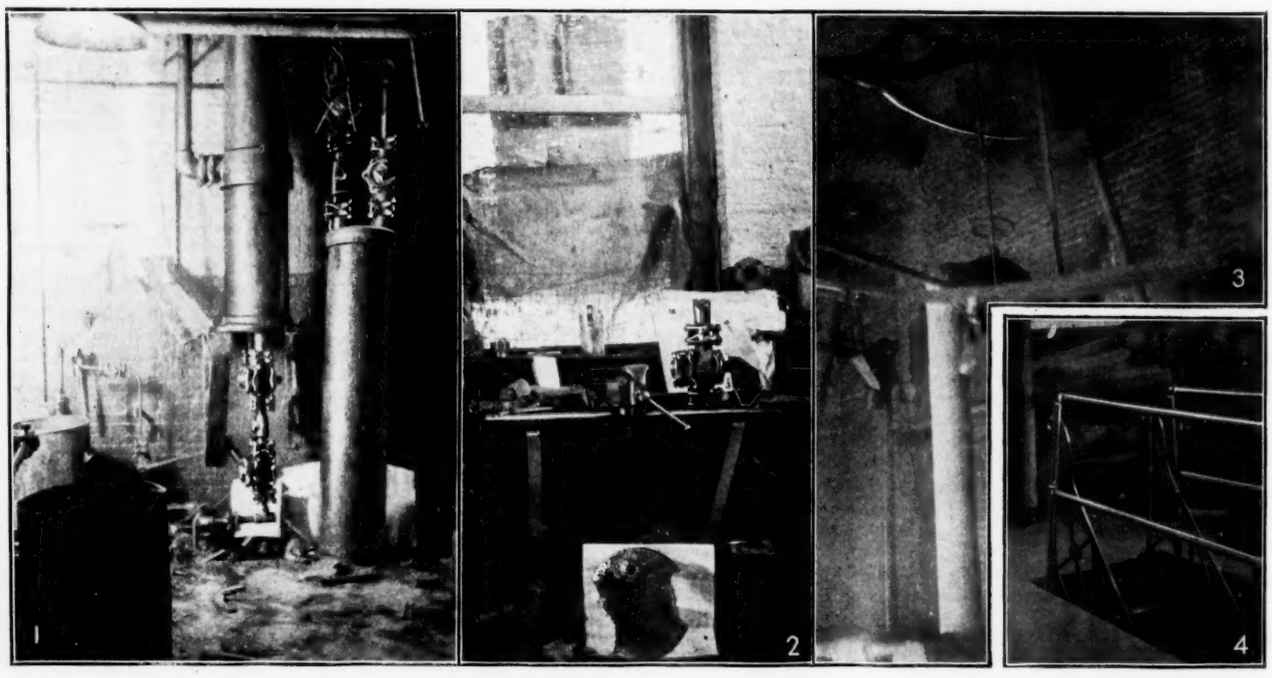
Harold S. Lord, formerly mechanical engineer with the General Electric Co., Lynn, Mass., is now with the Ruggles Machine Co., Poultney, Vt.

Royce L. Beers, formerly assistant fuel engineer with the United States Bureau of Mines, Pittsburgh, Penn., is now with the United States Radiator Corporation, Detroit, Mich.

Albion R. Davis, formerly connected with Gray & Davis, Inc., as chief draftsman, is now mechanical engineer of the Stone & Webster Engineering Corporation, Boston, Mass.

Armin S. Hoffman, formerly assistant engineer with the Texas Company, New York, is now connected with the engineering department of the Griscom Russell Co., New York.

C. L. Willis has been appointed manager of the New York branch of James Walker & Co., Ltd., succeeding A. G. Hardie, who has returned to the home office of the company in London, England.



FIGS. 1 TO 4. VIEWS OF THE PETER HAUCK AMMONIA EXPLOSION, HARRISON, N. J.
Fig. 1—Oil separator, the bottom head of which blew out. Fig. 2—Showing the head (bottom of picture). Fig. 3—The exploded gas line in the condenser room. Fig. 4—One of the two exits from the condenser room

H. A. Hoffman, formerly in the steam-flow meter department of the General Electric Co., is now in charge of the Philadelphia office of the Lagonda Manufacturing Co., in the Pennsylvania Building.

A. L. Humphrey, first vice-president and general manager of the Westinghouse Air Brake Co., Pittsburgh, Penn., has been elected president of the Union Switch and Signal Co., in accordance with merger proceedings of the two companies.

J. D. Cherry, who for years carried on an engineering specialties sales business in Chicago, has accepted a position as sales manager with the Roto Co., of Hartford, Conn., to have charge also of the company's sales organizations in this country and abroad.

Cass L. Kennicott, who for many years has been known as an expert in water softening, has become associated with the Permutit Co. and is now in charge of the company's Chicago office, at 208 South La Salle St., with F. S. Dunham, of the old organization, associated with him.

Prof. R. C. Carpenter reaches the retiring age at the end of the present college year and will sever his active connection with Sibley College, Cornell University, at that time. He retires in good health and expects to maintain his activities in the fields of engineering investigation and research for several years to come.

John A. Laing has been elected vice-president of the Pacific Power and Light Co., and Lewis A. McArthur, who had been assistant general manager, succeeds to the general managership, following the resignation of James E. Davidson, who has gone with the Electric Bond and Share Co., of New York. W. N. Voegtly has been appointed purchasing agent of the company to succeed C. H. Still, resigned.

ENGINEERING AFFAIRS

The Philadelphia Section of the A. S. M. E. will hold a meeting on Mar. 27. The subject will be, "District Heating," by Walter J. Kline.

The Buffalo Section of the A. S. M. E. will hold a meeting on Mar. 14. The subject discussed will be, "Standardization," by Karl W. Zimmerschied.

The Providence (R. I.) Section of the A. S. M. E. will hold a meeting on Mar. 28. An address will be made by Dr. Ira N. Hollis, president of the society.

The Chicago Section of the A. S. M. E. will hold a meeting on Mar. 16. There will be a general discussion of the problems presented in the training of the young engineer.

The Philadelphia Section of the A. S. M. E. will hold a meeting on Mar. 15. The subject will be, "The Design, Construction and Equipment of a Modern Military Aëroplane," by Jerome C. Hunsaker, assistant naval constructor, Navy Department.

The Steel Treating Research Club will hold a meeting in the rooms of the Detroit (Mich.) Engineering Society on Friday evening, Mar. 16. W. T. Whalen, of the Westinghouse Electric and Manufacturing Co., will give a lecture, supplemented by moving pictures, on "Steam Railroad Electrifications."

The New England Water Works Association will hold a meeting in Boston, Wednesday, Mar. 14, with headquarters at the Hotel Brunswick. The following papers will be read: "Statistics Relating to the New England Water Works Association," by W. S. Johnson; "Electrolysis—Troubles Caused Thereby and Remedies Which May Be Applied," by Prof. Albert F. Ganz; "Cast Iron Pipe Joints," by F. F. Forbes; also topical discussion.

The American Society of Mechanical Engineers will hold its spring meeting in Cincinnati, Ohio, May 21-24. On Tuesday, May 22, there will be a joint session with the National Machine Tool Builders' Association, which will be in charge of the Cincinnati local committee and a committee representing the Machine Tool Builders' Association. Papers will be presented on "Employees' Service Work" and "Industrial Education," as developed in Cincinnati. Another important session will be devoted to a discussion of problems relating to the manufacture of munitions. Sessions will also be held by the subcommittees on gas power and on machine-shop practice, and there will be at least one session devoted to miscellaneous papers. The Cincinnati local committee has arranged a very attractive entertainment program, including an especially attractive one for the ladies.

The American Institute of Electrical Engineers will hold its three hundred and thirty-first meeting on Apr. 13, 1917, in Schenectady, N. Y. The headquarters will be in the Edison Club, 60 Washington Ave. The meeting will be held under the auspices of the Standards Committee, and the general subject will be "Temperature Corrections." One paper will be presented on this subject by V. M. Montsinger. Four other papers on the same subject, which have been presented at previous meetings of the institute during this season, will be discussed: "Temperature Distribution in Electrical Machinery," by B. G. Lamme; "Rational Temperature Guarantees for Large Alternating-Current Generators," by F. D. Newbury; "Internal Temperatures of Alternating-Current Generators," by Ralph Kelly; and "Electrical-Machinery Tests, and Specifications Based on Modern Standards," by H. M. Hobart.

BUSINESS NOTES

The Ohio Steam Specialty Co., of Cleveland, Ohio, will soon place upon the market the "Ossco" safety water column and other specialties.

The Stroh Steel-Hardening Process Co., of Pittsburgh, Penn., has opened an office at 728 Monadnock Block, Chicago, with F. Lloyd Mark in charge.

L. S. Shaw & Co. announce the opening of their office in the Dime Bank Building, Detroit, Mich., where they will conduct a sales engineering business in power-plant equipment.

The H. W. Johns-Manville Co. announces that after Mar. 15 its Louisville (Ky.) branch office will be in the Speed Realty Co.'s newly erected building at the corner of Fourth Ave. and Guthrie St., with A. H. Voigt in charge.

Warren Webster & Co. announces that the Power Equipment Co., 131 State St., Boston, Mass., will represent its feedwater heater department in the New England territory, coöperating with the established branch office in Boston. John Jay, of the home office in Camden, will be in charge of the department.

The W. S. Barstow Management Association, 50 Pine St., New York, announces its incorporation to supervise the management of all public-utility properties controlled by the General Gas and Electric Co., the Eastern Power and Light Corporation and W. S. Barstow & Co., Inc. E. L. West has been elected president of the new corporation.

TRADE CATALOGS

Duplex Power Pumps. The John H. McGowan Co., Cincinnati, Ohio. Bulletin No. 80. Pp. 34; 6x9 in.; illustrated.

Boyer Railway Speed Recorder. Chicago Pneumatic Tool Co., Fisher Building, Chicago, Ill. Bulletin No. 263; pp. 28; 6x9 in.; illustrated.

Hydraulic Valves, Fittings and Accessories. Nason Manufacturing Co., 71 Fulton St., New York. Section H, Catalog No. 16. Pp. 8; 7¼x10½ in.; illustrated.

Motor Trucks of America, Volume V. The B. F. Goodrich Co., Akron, Ohio. Pp. 164; 7x10 in. This contains photographs and specifications of various motor trucks.

Lagonda Condenser Cleaners. The Lagonda Manufacturing Co., Springfield, Ohio. Bulletin No. O-2. Pp. 16; 6x9 in.; illustrated. Describes and illustrates use of Lagonda cleaners.

S K F Self-Aligning Ball-Bearing Hangers and Pillow Blocks. S K F Ball Bearing Co., Hartford, Conn. This bulletin is neatly designed and arranged, exceptionally well illustrated and contains valuable tables and engineering data upon lubrication, testing lubricants, mounting, felt seals, belt saving, countershafts, etc. Besides describing the bearing and hanger, announcement is made of the S K F Engineering Service. We understand the booklet is for free distribution.

Laclede-Christy Chain-Grate Stoker. The Laclede-Christy Clay Products Co., St. Louis, Mo. Specifications and Proposal. Pp. 20; 8½x11 in.; illustrated. Not only has this catalog been gotten up in an artistic manner with exceptionally well-executed halftone illustrations, but it contains a clear treatise on the equipment dealt with from a mechanical standpoint, considered under three heads: The stoker proper as a machine for handling the coal and ash; the stoker accessories; and the furnace construction surrounding the burning fuel. A perusal of this catalog will be of assistance to any engineer who is interested in chain-grate stokers.

Ladd Water-Tube Boilers. The George T. Ladd Co., Pittsburgh, Penn. Catalog No. 17; pp., 30; 8¼x11 in. This is an extremely attractive catalog. Not only is the tint of the paper of an artistic color, but the text and halftone illustrations are well executed and arranged. Most of the line drawings are printed in colors to distinguish the common brick from the firebrick used in the boiler setting. The illustrations presented show the general design of the boiler with and without a superheater and the method of suspending the boiler from a steel-girder framework. Attention is called to the types and sizes built, details of construction, efficiency and upkeep. As a matter of fact, the Ladd is the Milne water-tube boiler and is now manufactured under its new name. The builders state that they are prepared to furnish the boiler in sizes up to 3000 hp. The larger sizes are arranged with double furnaces and combine the standard design of the type together with a multipass arrangement of the gases and the separation of the superheaters in the end walls. It is built in conformity with the A. S. M. E. Code. The catalog shows that the multiple-drum boiler with double furnaces is made up of practically two units, the upper drums of which are tied with a circulating pipe.

THE COAL MARKET

Boston—Current quotations per gross ton delivered alongside Boston points as compared with a year ago are as follows:

ANTHRACIT

	Circular[1]		Individual[1]	
	Mar. 10, 1917	One Year Ago	Mar. 10, 1917	One Year Ago
Buckwheat	$3.40@4.40	$3 05@3.20	$5.50@5.75	$3.25@3.50
Rice	.....	2 50@2.65	.....	2.70@2.95
Boiler	2.75@3.75	.....	.....	.....
Barley	2.65@3.65	2.20@2 35	.....	2.35@2.60

BITUMINOUS

Prices per gross ton for Boston delivery are as follows:

	F.o.b. Mines*		Alongside Boston†	
	Mar. 10, 1917	One Year Ago	Mar. 10, 1917	One Year Ago
Clearfields	$5.90@7.00	$1.45@2.00	$11.50@11.75	$4.25@5.00
Cambrias and Somersets	6.15@7.25	1.60@2.15	11.75@12.00	4.60@5.40

Pocahontas and New River, f.o.b. Hampton Roads is $7@7.25, as compared wtih $2.80@2.90 a year ago; on cars Boston price is $14@15, against $5@5.25 a year ago.

*All-rail rate to Boston is $2 60. †Water coal.

New York—Current quotations per gross ton f.o.b. Tidewater at the lower ports* as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	Mar. 10, 1917	One Year Ago	Mar. 10, 1917	One Year Ago
Buckwheat	$2.75	$2.75	$6.50@6.75	$2.85@3.25
Rice	2 20	2.25	4.50@5.25	2.10@2.30
Barley	1.95	1.75	4.00@4.25	1.90@2.00

Quotations at the upper ports are about 5c. higher.

BITUMINOUS

	South Amboy	Port Reading	Mine Price
Clearfield	$7.75@8.00	$7.75@8.00	$6.25@6.50
South Forks	7.75@8.00	.....	6 25@6.50
Nanty Glo	7.75@8.00	.....	6.25@6.50
Somerset	7.75@8.00	7.75@8 00	5.75@6 00
Quehamoning	7.75@8.00	7.75@8.00	6.00@6.25

*The lower ports are: Elizabethport, Port Johnson, Port Reading, Perth Amboy and South Amboy. The upper ports are: Port Liberty, Hoboken, Weehawken, Edgewater or Cliffside and Guttenberg. St. George is in between and sometimes a special boat rate is made. Some bituminous is shipped from Port Liberty. The freight rate to the upper ports is 5c. higher than to the lower ports.

Philadelphia—Prices per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide shipment are as follows:

	Line		Tide	
	Mar. 10, 1917	One Year Ago	Mar. 10, 1917	One Year Ago
Buckwheat	$2.50	$1.55	$3 40	$2.30
Rice	2.10	.90	3.00	1.80
Boiler	1.95	....	3.15	....
Barley	1.85	.55	2.05	1.30

Pittsburgh—Price of steam coal per net ton f.o.b. mine, Pittsburgh district:

	Mar. 10, 1917	One Year Ago
Slack	$4.75@5.00	$1 15@1.20
Mine-run	5.00	1.25@1.30
¾-in.	5.00	1.35@1.40

Add 40c. per ton for freight charge to Pittsburgh.

Chicago—Current price per net ton f.o.b. mines are as follows:

	Williamson and Franklin Counties	Saline and Harrisburg	West Virginia Smokeless	Springfield	Clinton and Sullivan Counties
Steam lump	.....	$3.50@3.75	.....	$2.35@2 75	$3.00@3.25
Lump	3.75@4 00	3.75	$5.00	2.50@3.00	3.50@3.75
Egg	3.75@4.00	3.75	5.00	2.50@2.75	3.00@3.50
Nut	.....	3.50@3.75	.....	2 75@3.00	3.00@3.50
No. 1 nut	3.75@4.00	.....	.....	.....	.....
No. 2 nut	3.75@4.00	.....	.....	.....	.....
No. 3 nut	3.50@3.75	.....	.....	.....	.....
No. 1 washed	3.50@3.75	.....	.....	.....	.....
No. 2 washed	3.50@3.75	.....	.....	.....	.....
Mine-run	3.50@3 75	3.25@3.50	4.50@4.75	2.35@2.50	3.00@3.25
Screenings	3.00@3.25	3.00@3.25	.....	2.15@2.25	3.00@3.25

Hocking lump, $4.25@4.50; splint lump, $4.25@4 50.

St. Louis—Price per net ton f.o.b. mine a year ago as compared with today are as follows:

	Williamson and Franklin Counties		Mt. Olive and Staunton		Standard	
	Mar. 10, 1917	One Year Ago	Mar. 10, 1917	One Year Ago	Mar. 10, 1917	One Year Ago
6-in. lump	$3.00@3.25	$1.50@1.75	$2.85	$1 25@1.50	$2.25@2.50	$1.10@1.25
2-in. lump	3 00@3.25	1.40@1.50	2.75	1 15@1.25	2 00@2.25	.95@1.10
Steam egg	3.00@3.25	1.40@1.50	2 75	1.15@1 25	2.00	.90@1 10
Mine-run	2.75@3 00	1.10@1.15	2.75	1.10@1 15	2.00	.90@1.00
No. 1 nut	3.00@3.25	1.30@1.40	2.75	1 25@1.50	2.25	.90@1.10
2-in. screen.	2.50@2.75	.90@1.00	2 35	.75@ .90	1.85@2.00	.65@ .80
No. 5 washed.	2 50	.90@1.00	2.00	.75@ .85	1 75	.65@ .75

Williamson-Franklin rate St. Louis, 72½c.; other rates, 57½c.

Birmingham—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Washed Mine-Run
Pratt	$3.25@3 50	$2.50@3.00
Big Seam	2.50@3 00	.....
Black Creek	3.25@3.50	3.25@3.50
Carbon Hill	2.75@3 00	2.75@3.00
Cahaba	3.00@3.50	3.00@3 50

[1]Individual prices are the company circulars at which coal is sold to regular customers irrespective of market conditions. Circular prices are generally the same at the same periods of the year and are fixed according to a regular schedule.

PROPOSED CONSTRUCTION

Ala., Gadsden—The Alabama Power Co. will install a transmission line around the southern outskirts of the city.

Ariz., Snowflake—City will install an electric-light plant.

Ariz., Tombstone—F. L. Wright has been granted a franchise to install an electric-light plant. Estimated cost, $15,000.

Ark., Batesville—City plans to improve the electric-light plant.

Calif., San Bernardino—City will install an electric-light plant. F. Smith, City Engr.

Calif., Vallego—Bids will soon be received by Bureau of Supplies and Accounts, Navy Dept., Washington, D. C., for furnishing at the Navy Yard, Mare Island, under Schedule 802, 264 brass grease cups; Schedule 776, 8 complete torsion meters.

Colo., Haxtum—The City Council will install an electric-light plant. Estimated cost, $15,000.

Ga., Columbus—The City Council plans to hold an election to vote on bonds to install an electric-light plant.

Idaho, Shelley—The Shelley Light and Power Co. plans to reconstruct its local distributing lines and will extend its transmission lines to several neighboring towns within a radius of 6 mi. A. C. Schweitzer, Supt.

Ill., Chicago—The Peoples Gas, Light and Coke Co., 122 South Michigan Ave., is having plans prepared for a gas plant. Estimated cost, $30,000. R. Schenck, Arch.

Ind., Bremen—(Official)—Town is receiving bids Apr. 11 for 2 motor-driven plunger type and 1 centrifugal type pumps and accessories for electrifying the present steam plant. E. M. Wright, Town Clk.

Ind., Nappanee—The Hawks Electric Co., Goshen, contemplates purchasing the local electric-light plant and will improve the system. C. Yoder, Goshen, Ch. Engr.

Ind., Richmond—The Bd. Pub. Wks. will improve the electric-light plant. Estimated cost, $50,000. F. Charles, City Engr.

Kan., Agra—City will hold an election Apr. 2 to vote on $8000 bonds to install an electric-light plant.

Kan., McPherson—City has retained Black & Veatch, Interstate Bldg., Kansas City, Mo., to prepare plans for improving the electric-light plant, including 250-hp. water-tube boiler, 300-kv.a. direct-connected steam-driven generating unit, feed-water heater, boiler-feed pump, high-pressure steam piping and brick or concrete chimney. A. Grosbeck, Supt.

Kan., White Water—The Kansas Gas and Electric Co., Wichita, will install 9-mi. transmission line and will improve the system.

Ky., Tompkinsville—The Tompkinsville Electric Light and Ice Co. plans to rebuild its plant which was recently destroyed by fire. J. B. Brown, Gen. Mgr.

Md., Midland—The Midland Electric Light Co. has secured the right-of-way to install a high-tension transmission line between Midland and Junction Park.

Mass., Holyoke—City will build an electric-light plant on the river front and will install new scrubber, exhauster, condenser, 2 extractors and station meter. J. J. Kirkpatrick, Mgr.

Mich., Hesperia—The Frugale Power Co. will rebuild its dam and install new wheels and generators.

Minn., Ruthton—City will install an electric-lighting system.

Minn., St. Paul—The St. Paul Gas Light Co., 6th and Jackson St., will install a hydro-electric power plant.

Mo., Clarkton—L. Dunn has purchased the municipal electric-light plant and will enlarge and improve the system.

Mo., Versailles—City voted in favor of issuing $6000 bonds to make improvements at the electric-light plant.

N. Y., Le Roy—The Empire Power Corp. will install an electric-light plant. G. P. Jones, Pres.

N. Y., New York—Bids will soon be received by Bureau of Supplies and Accounts, Navy Dept., Washington, D. C., for furnishing at the Navy Yard, Brooklyn, under Schedule 786, 166,000 ft. telephone cord; Schedule 784, 1300 ft. unlined linen fire hose; Schedule 776, 8 complete torsion meters; Schedule 787, 30,600 loofa spongers; Schedule 786, 520,000 ft. bell wire, 47,000 ft. twin conductor wire; Schedule 784, 125,000 ft. single rubber-covered wire.

N. Y., New York—(Borough of Manhattan)—The Interborough Rapid Transit Co., 165 Broadway, has had plans prepared for a 1-story, 49 x 108-ft. brick transformer station at 150-154 East 57th St. Estimated cost, $45,000. G. H. Pegram, 165 Broadway, Arch.

N. Y., New York—(Borough of Manhattan)—The Interborough Rapid Transit Co., 165 Broadway, has had plans prepared for a 2-story, 49 x 108-ft. brick transformer station and telephone exchange at 122-126 Park Row. Estimated cost, $45,000. G. H. Pegram, 165 Broadway, Arch.

N. Y., Utica—Bosser Corp., 1019 Hickory St., is having plans prepared for a 1-story power plant. Estimated cost, $50,000. J. S. Schneider, 1019 Hickory St., Arch.

S. D., Centerville—The Centerville Milling Co. will install an engine, additional boiler, water wheel, generator and concrete dam. R. W. Nash, Supt.

S. D., Dell Rapids—City is having plans prepared for an electric-light and power plant. Estimated cost, $25,000. Electric Development Co., Omaha, Neb., Engr.

Tex., Ft. Worth—The County Gas Co. has been granted a franchise for laying gas pipe lines.

Wis., Juda—C. H. Swartzlow will construct a steam-operated electric-light and power plant. Estimated cost, $7500.

Wis., Manitowoc—The Wisconsin Securities Co., 1410 First National Bank Bldg., Milwaukee, is having plans prepared for an electric power plant. Estimated cost, $250,000. Woodmansee-Davidson Co., 1426 First National Bank Bldg., Milwaukee, Arch.